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# The Propulsive Small Expendable Deployer System (ProSEDS)

NASA Grant NAG8-1605

**Annual Report #3**

For the period 1 August 2001 through 31 July 2002


Principal Investigator

Enrico C. Lorenzini


July 2002

Prepared for

National Aeronautics and Space Administration

Marshall Space Flight Center, Alabama 35812


Smithsonian Institution

Astrophysical Observatory

Cambridge, Massachusetts 02138


The Smithsonian Astrophysical Observatory
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Enrico C. Lorenzini

Co-Investigators
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## SCOPE

This is the Annual Report #3 for Grant NAG8-1605 entitled "The Propulsive Small Expendable Deployer System (ProSEDS)" prepared by the Smithsonian Astrophysical Observatory for NASA Marshall Space Flight Center. This report covers the period of activity from 1 August 2001 through 30 July 2002. The technical officer for this grant is Leslie Curtis at NASA MSFC.

## SUMMARY

This Annual Report covers the following main topics:

*1. Updated Reference Mission*

The reference ProSEDS mission is evaluated for an updated launch date in the Summer of 2002 and for the new 80-s current operating cycle. Simulations are run for nominal solar activity condition at the time of launch and for extreme conditions of dynamic forcing. Simulations include the dynamics of the system, the electrodynamics of the bare tether, the neutral atmosphere and the thermal response of the tether.

*2. Evaluation of power delivered by the tether system*

The power delivered by the tethered system during the battery charging mode is computed under the assumption of minimum solar activity for the new launch date.

*3. Updated Deployment Control Profiles and Simulations*

A number of new deployment profiles were derived based on the latest results of the deployment ground tests. The flight profile is then derived based on the friction characteristics obtained from the deployment tests of the F-1 tether.

*4. Analysis/estimation of deployment flight data*

A process was developed to estimate the deployment trajectory of the endmass with respect to the Delta and the final libration amplitude from the data of the deployer turn counters. This software was tested successfully during the ProSEDS mission simulation at MSFC EDAC.

# 1. Updated Reference Mission

## 1.1 Introduction

We recall in this brief introduction a few general information about the Propulsive Small Expendable Deployment System (ProSEDS) in order to spare the reader from looking up this basic information in other documents. ProSEDS will carry out a demonstration of a bare electrodynamic tether for propulsion. The system will fly as a secondary payload on a Delta II and it will be deployed from the 2nd stage (see Fig. 1). The electrodynamic forces generated by the current flowing in the conductive tether are expected to strongly increase the decay rate of the Delta stage. The reader should consult references[1 2 3 4 5] for a more detailed description of ProSEDS and the principles of operation of bare-tether anodes.

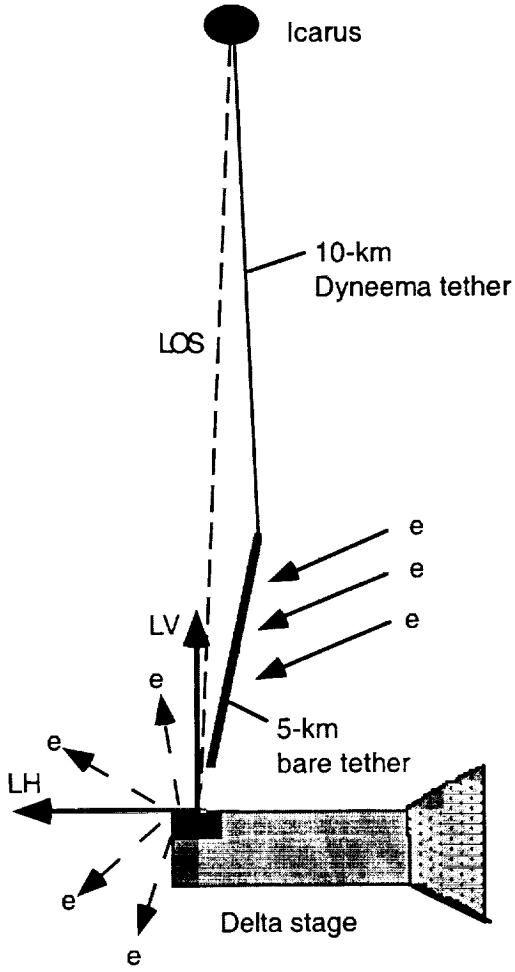


**Figure 1** Schematic of ProSEDS on Delta 2nd stage

Electrons are collected along the upper portion of the bare tether which is positively biased with respect to the surrounding plasma. They are then reemitted into the ionosphere at the Delta stage by an active hollow cathode device. The (electronic) current flowing along the tether from its top to the bottom interacts with the Earth's magnetic field to produce an electrodynamic drag force which decreases the orbit of the Delta stage.

The performance of ProSEDS will be assessed on the basis of the decay rate of the Delta stage which is affected (for a given tether design) by the plasma conditions at mission time. The launch date of ProSEDS has changed throughout its development with the latest launch date being in the Summer of 2002. Moreover, the modes of operation of the tether current (i.e., the operating cycle) have also changed, as explained later on, resulting in a strongly increased decay rate.

## 1.2 New Mission Parameters and Current Operating Cycles

The ProSEDS mission had some notable changes in terms of launch date, starting altitude and current operating cycle. The launch date was moved to the Summer of 2002, the starting altitude was decreased from 400 km to roughly 360 km and the secondary operating cycle (with 80-s period) now consists of 50-s battery charging and 30-s shunt mode (see Fig. 3). The original primary cycle (with 60-s period as shown in Fig. 2) is utilized during the first 5 orbits while the secondary cycle is utilized thereafter.

The reference mission for the scheduled launch date of July 25$^{th}$, 2002 is analyzed in the following. The new launch date impacts the system performance because the current in the tether is a function of the plasma density which, in turn, is a function of the solar activity. Consequently, the electrodynamic drag force and the reentry time change because of the changed plasma conditions. We are presently in solar cycle 23 with the solar activity going down towards a minimum of activity currently estimated to happen around the years 2007-2008. More importantly the ProSEDS tether current operating cycle has been changed. The older cycle consisted of 7 orbits of primary operating cycle followed by a secondary cycle. The old secondary cycle consisted of 35-s open circuit mode, 5-s resistor mode, 5-s shunt mode and 35-s battery charging mode. The new secondary operating cycle consists of 30-s shunt mode and 50-s battery charging mode. The change has a positive effect (as shown later on) on the decay rate of the orbit because there are no periods in the secondary operating cycle in which the tether current is off (open circuit mode) or severely limited (high resistor mode).

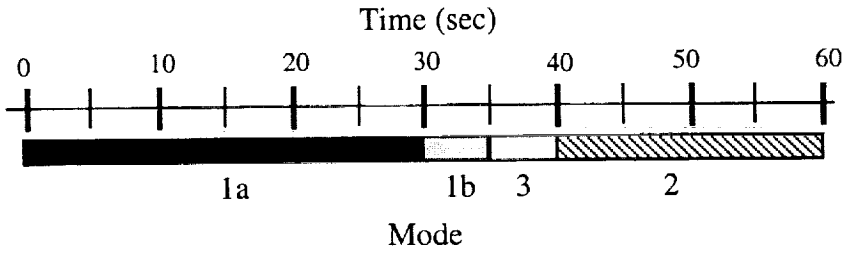


**Figure 2** Operating cycle #1 (60-sec cycle) - Operation on Primary Battery

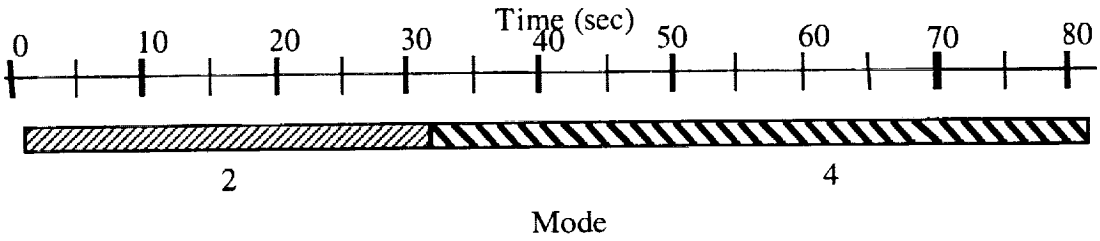


**Figure 3** New operating cycle #2 (80-sec cycle) - Operation on Secondary Battery

Mode 1a is open circuit, plasma contactor OFF
Mode 1b is open circuit, plasma contactor ON
Mode 2 is SHUNT mode
Mode 3 is RESISTOR mode
Mode 4 is BATTERY CHARGE mode

Operating cycle #1 is on primary battery (first 5 orbits)
New operating cycle #2 is on secondary battery (after the first 5 orbits)

In the following, we show the results of the new reference mission simulation. The initial conditions and orbital parameters assumed for the reference simulation are as follows:

Launch date and time:

25 July 2002; UTC = 00:15:00 hr:min:s (at first perigee pass)

Orbital elements (from Boeing):

Semimajor axis = 6736.556794 km

Eccentricity = 0.001305

(Initial orbit approx: 350 km x 367 km, with respect to a spherical Earth)

Inclination = 35.363 deg

Right Ascension (RAAN) = 60.296 deg

Argument of perigee = 289.996 deg

Simulation started at first perigee pass, i.e., true anomaly = 0

Environmental conditions:

Nominal solar activity (50% percentile): Rz = 94 (SunSpot Number); IG = 132 (Ionospheric Global Index); F10.7 = 141 (radio flux), Ap = 15 (geomagnetic index).

System parameters:

Satellite mass = 21.4 kg;

Delta mass = 994 kg

Tether mass = 10-kg wire and 1.5-kg Dyneema

Wire external diameter = 1.2 mm

Dyneema average cross section: ~1.2mm x 0.2mm

Tether optical properties:

Dyneema: $\alpha_S = 0.1$, $\varepsilon_{IR} = 0.5$;

C-COR coated wire: $\alpha_S = 0.9$, $\varepsilon_{IR} = 0.8$.

Tether mechanical properties: EA = 15,000 N; E'A ≈ 2000 Ns.

Wire ohmic resistance = 250 ohm at 20 °C

Electrical operating cycle:

The primary cycle is activated at Delta Time = 12,666 s which corresponds to 4700 s after simulation start (when ProSEDS is off the coast of Brazil). The secondary cycle is activated after 5 orbits, i.e., at about 32,200 s after simulation start.

Results of the new reference mission simulation are shown in the following figures. Although these results have been computed for July 25, 2002, they are also valid throughout the Summer of 2002 because the ionospheric indexes change only a little over those months as explained in the next subsection.

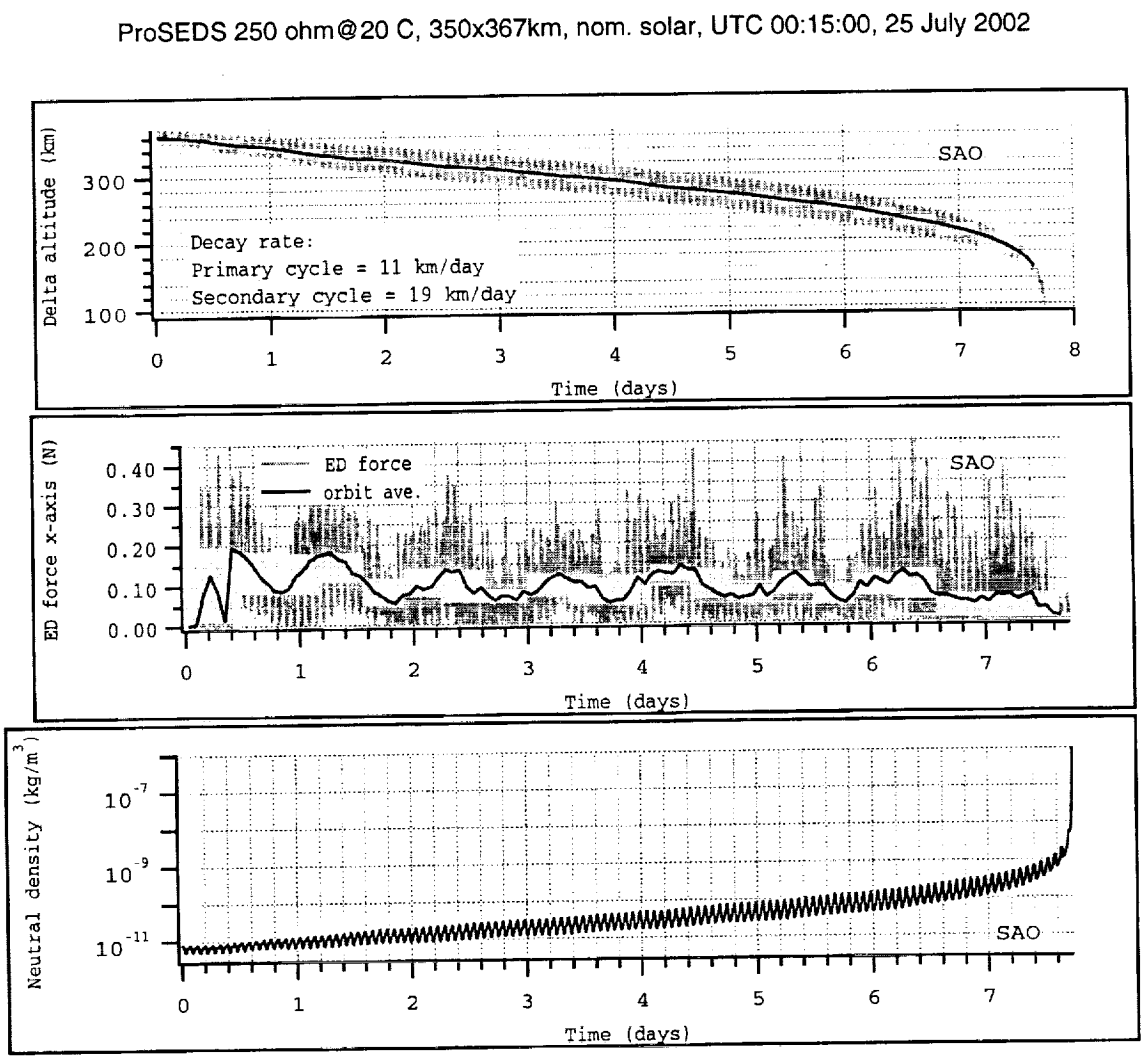


**Figure 4** Simulation results for Summer 2002 launch; nominal solar condition

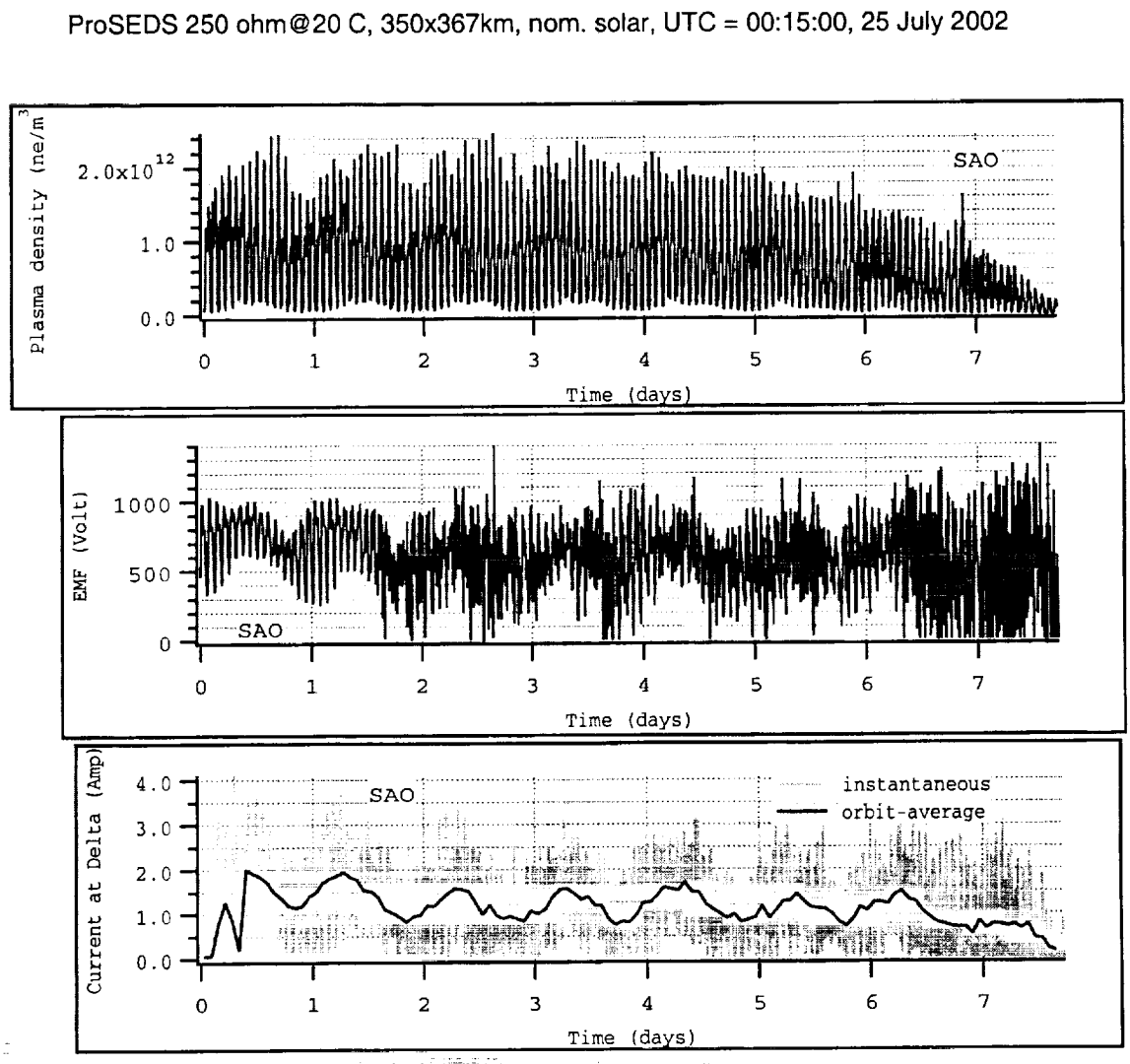


**Figure 5** Simulation results for Summer 2002 launch; nominal solar condition

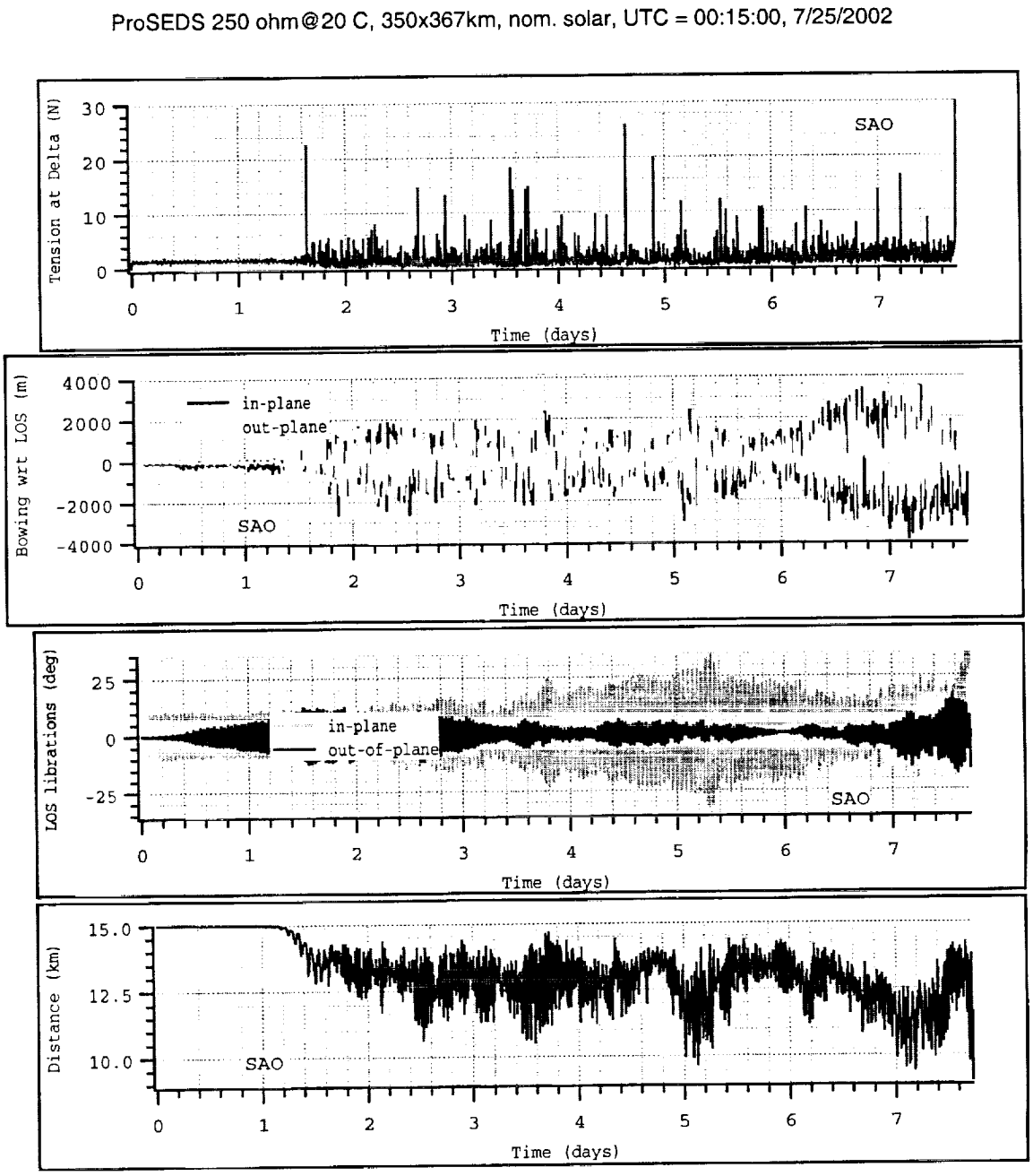


**Figure 6** Simulation results for Summer 2002 launch; nominal solar condition

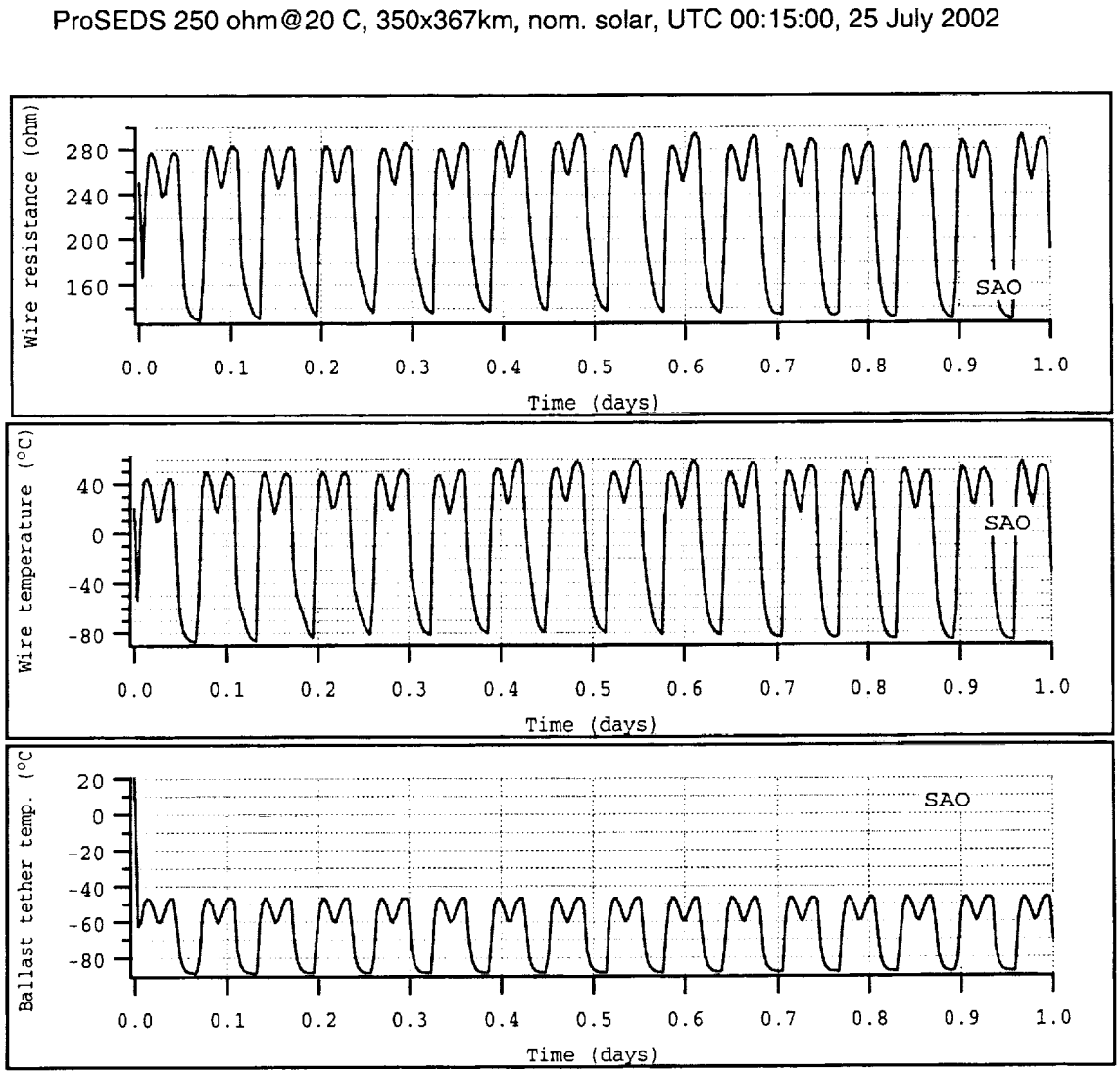


**Figure 7** Simulation results for Summer 2002 launch; nominal solar condition

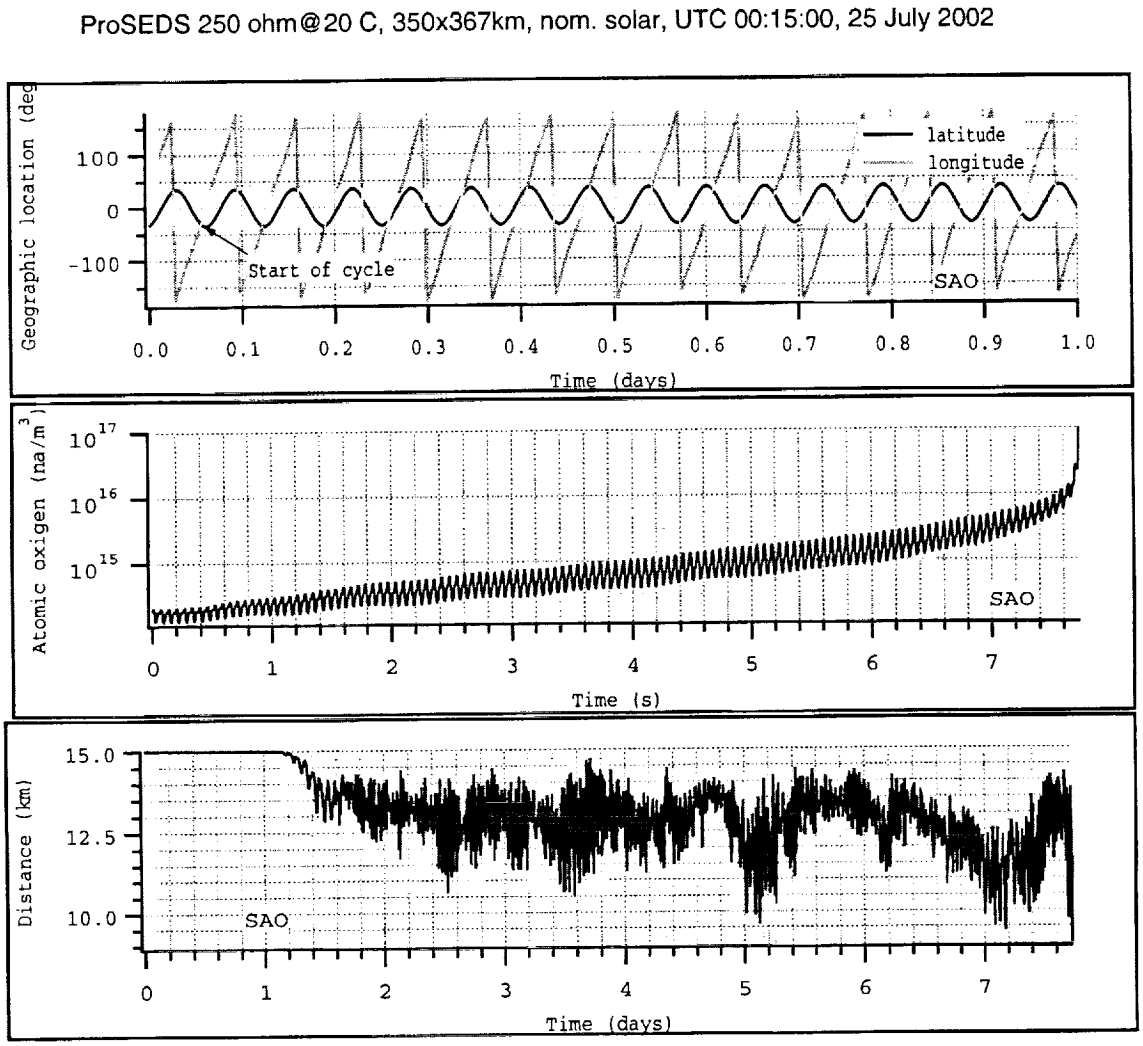


**Figure 8** Simulation results for Summer 2002 launch; nominal solar condition

The results show that the new secondary operating cycle almost doubles the decay rate of ProSEDS with respect to previous scenarios. The system dynamics is also more strongly excited with the excitation increasing steeply after one day in orbit. The excitation is the result of a complex skip-rope motion in which the in-plane and out-of-plane motion are coupled as was studied in Refs. [6]. The most noticeable indicator of this motion is the distance from the Delta to the end mass which is plotted in Figure 6. The fact that this distance does not go to zero suggests that the motion is not a planar motion but rather a coning motion resulting from a coupling between the in-plane and out-of plane degrees of freedom. The system dynamics is quite strong as it can be seen from Figure 6. The tension spikes in the tension plot result from recoiling after the tether has lost tension while there was a substantial shortening of the distance between the end mass and the Delta. The system, however, remains stable and it never topples over. The out-of-plane libration amplitude builds up to somewhat less than 30° at around 5.5 days and then decreases again; most likely because of an energy transfer between degrees of freedom.

If the tether were to remain intact (neglecting the effect of atomic oxygen and possibly a fatal micrometeoroid impact) the Delta stage would reenter the atmosphere before 8 days. However, this situation is only theoretical because the atomic oxygen will chew the Dyneema tether before the system encounters the dense atmosphere. The area below 250 km is were the Dyneema degradation due to atomic oxygen will become strong. The Dyneema tether will likely fail below that altitude, leaving the electrodynamic system is an uncertain state of functionality. Consequently, the rate of decay will slow down significantly after the tether severance with respect to the simulated decay rate that does not take a possible tether cut into account.

## 1.3 Applicability of results to later launch dates

We are presently in the solar cycle 23 during which the solar activity peaked in April-June 2000. Consequently, the solar activity and the plasma density (that is a function of the solar activity) will decrease over the next few years. The plasma density in the International Reference Ionosphere (IRI95) model is a function of two solar indexes (other than the point location): the Sun spot number (Rz) and the Ionospheric global index (IG). Figure 9 shows the prediction of the Sun spot number for this solar cycle and the next inclusive of high (95% percentile) and low (5% percentile) predicted values. Figure 10 shows the only available prediction of the Ionospheric global index (IG).

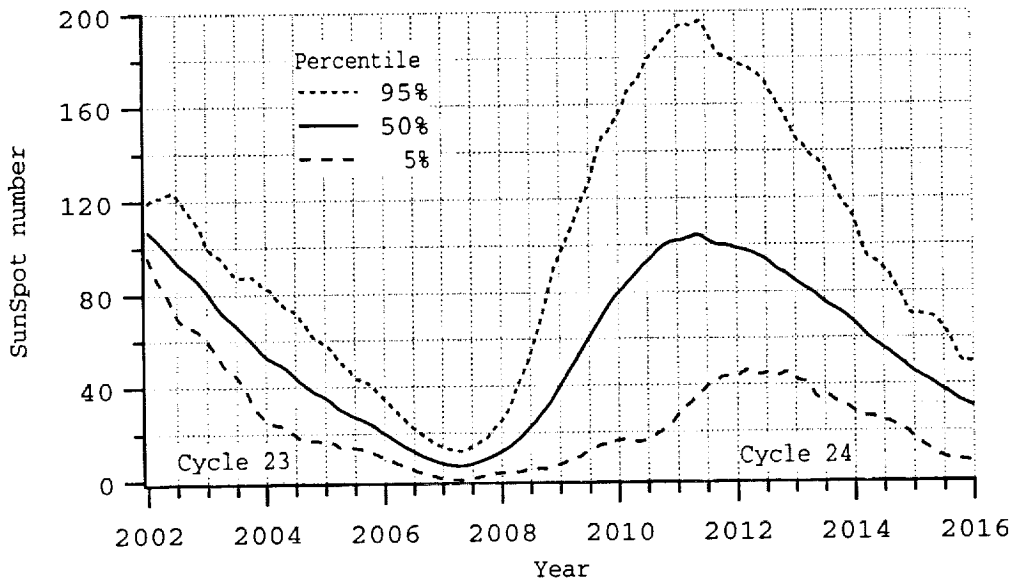


**Figure 9** Sunspot number predictions [NASA MSFC]

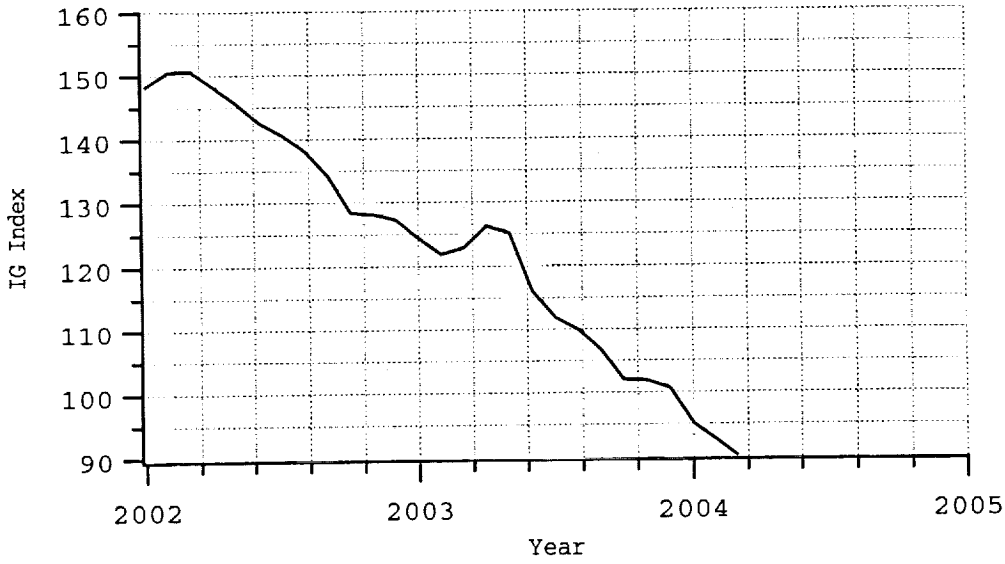


**Figure 10** Ionospheric Global Index (IG) prediction [Rutherford Appleton laboratory]

The change of these two indexes over the 3 months of the Summer 2002 is fairly moderate and consequently the result of the July 25th simulation are valid in good approximation throughout the Summer of 2002.

## 1.4 Extreme electrodynamic forcing

For the purpose of evaluating the system behavior and stability under maximum forcing of the electrodynamic drag a case was run for a plasma density that is (artificially) twice the plasma density under nominal conditions.

The double plasma density increases the decay rate to 23 km/day averaged over six days of secondary cycle operation. Figures 11-15 show the response of the system under these extreme conditions of plasma density. It is notable that the decay rate does not double with respect to the baseline case thanks to the ability of the bare tether to adjust in part to changing plasma conditions.

The dynamic response of the system is stable. The growth of the in-plane libration is actually less than for nominal solar conditions. The higher growth of the in-plane libration in the nominal case was likely due to a transfer of energy from the out-of-plane to the in-plane degrees of freedom as it can be inferred from Figure 6. This points again to the strongly non-linear characteristics of this system dynamics. The loss of tether tension most likely plays a key role by changing the phase relationship among degrees of freedom and forcing terms after the tether rebound and consequently transferring energy from some oscillations to others in a fairly random fashion.

The conclusion is that the overall system stability is not impaired by a doubling of the plasma density.

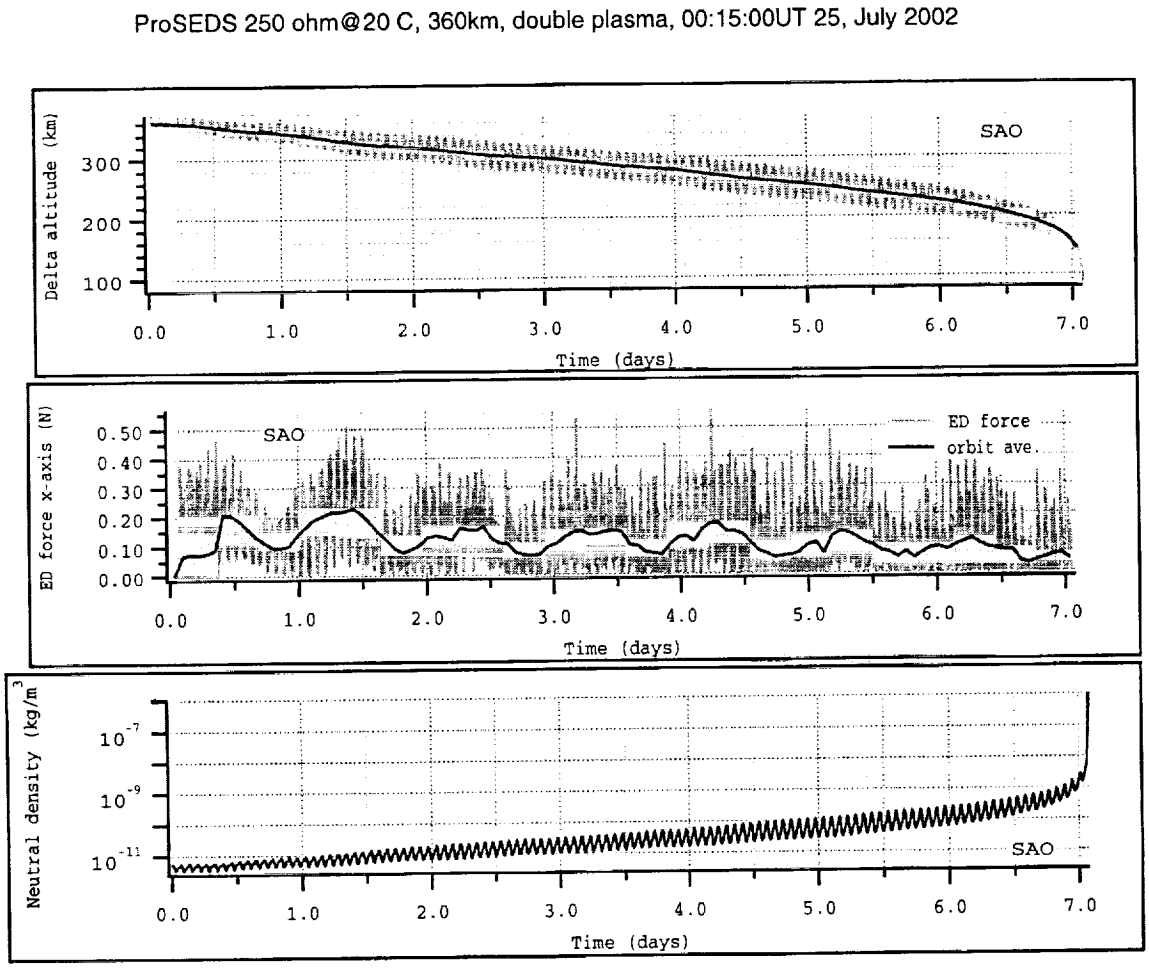


**Figure 11** Results for Summer 2002 launch, plasma density twice nominal

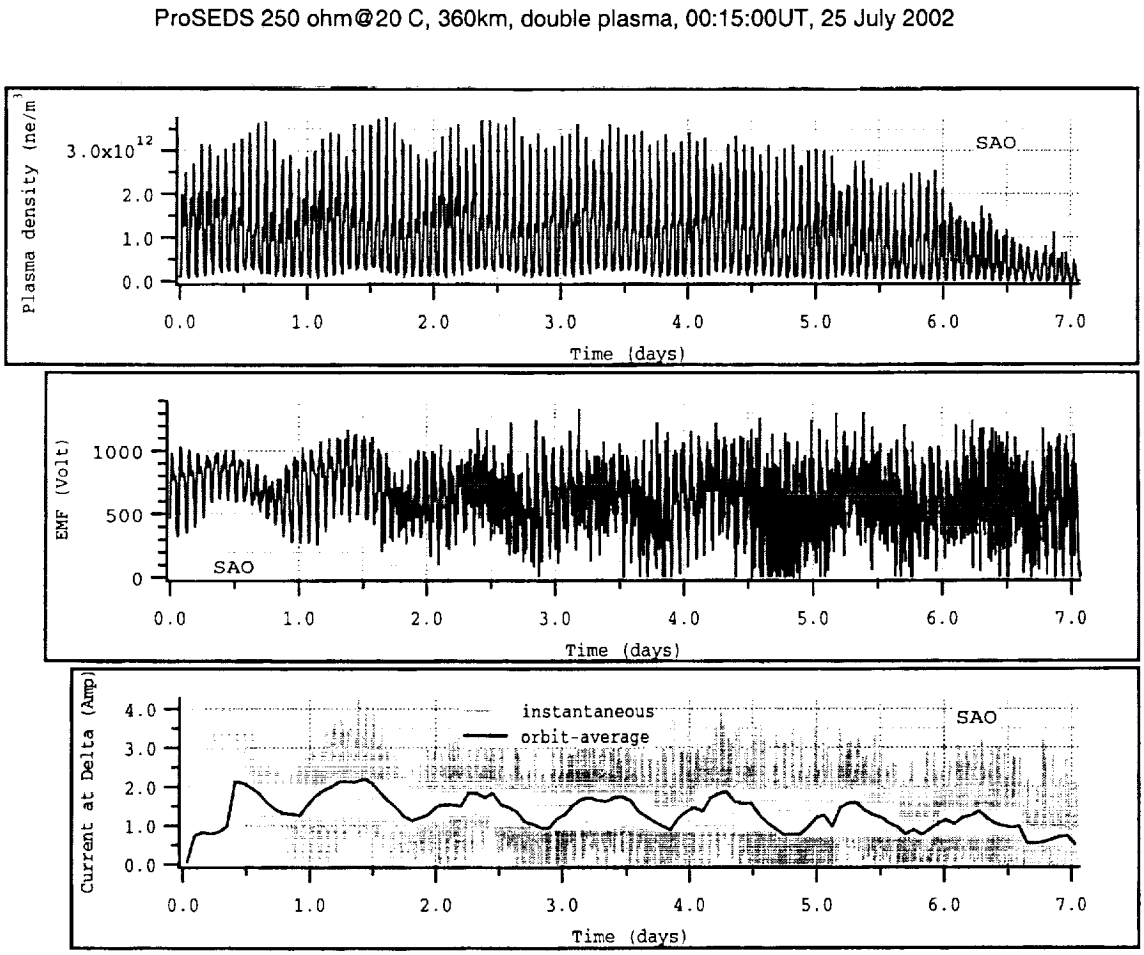


**Figure 12** Results for Summer 2002 launch, plasma density twice nominal

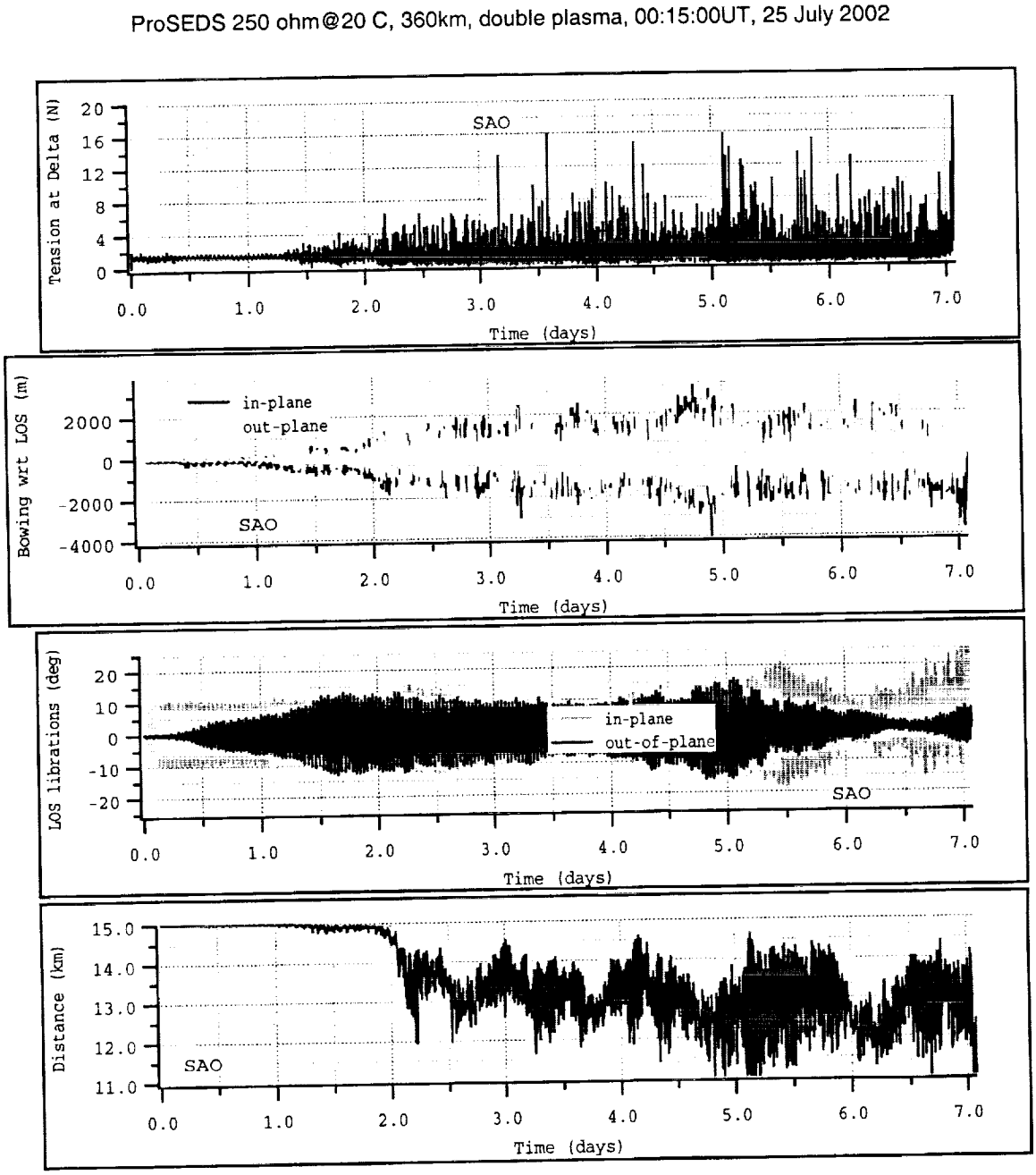


**Figure 13** Results for Summer 2002 launch, plasma density twice nominal

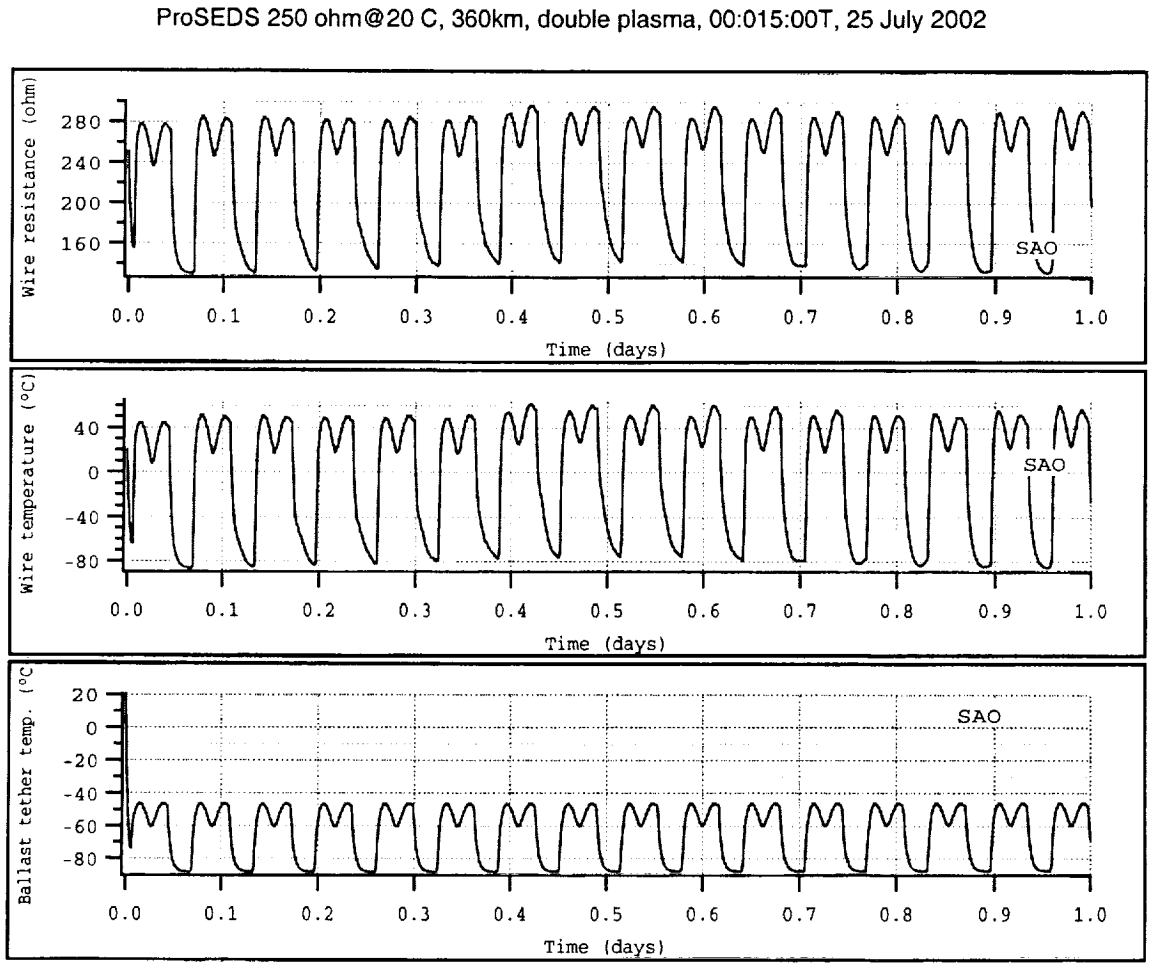


**Figure 14** Results for Summer 2002 launch, plasma density twice nominal

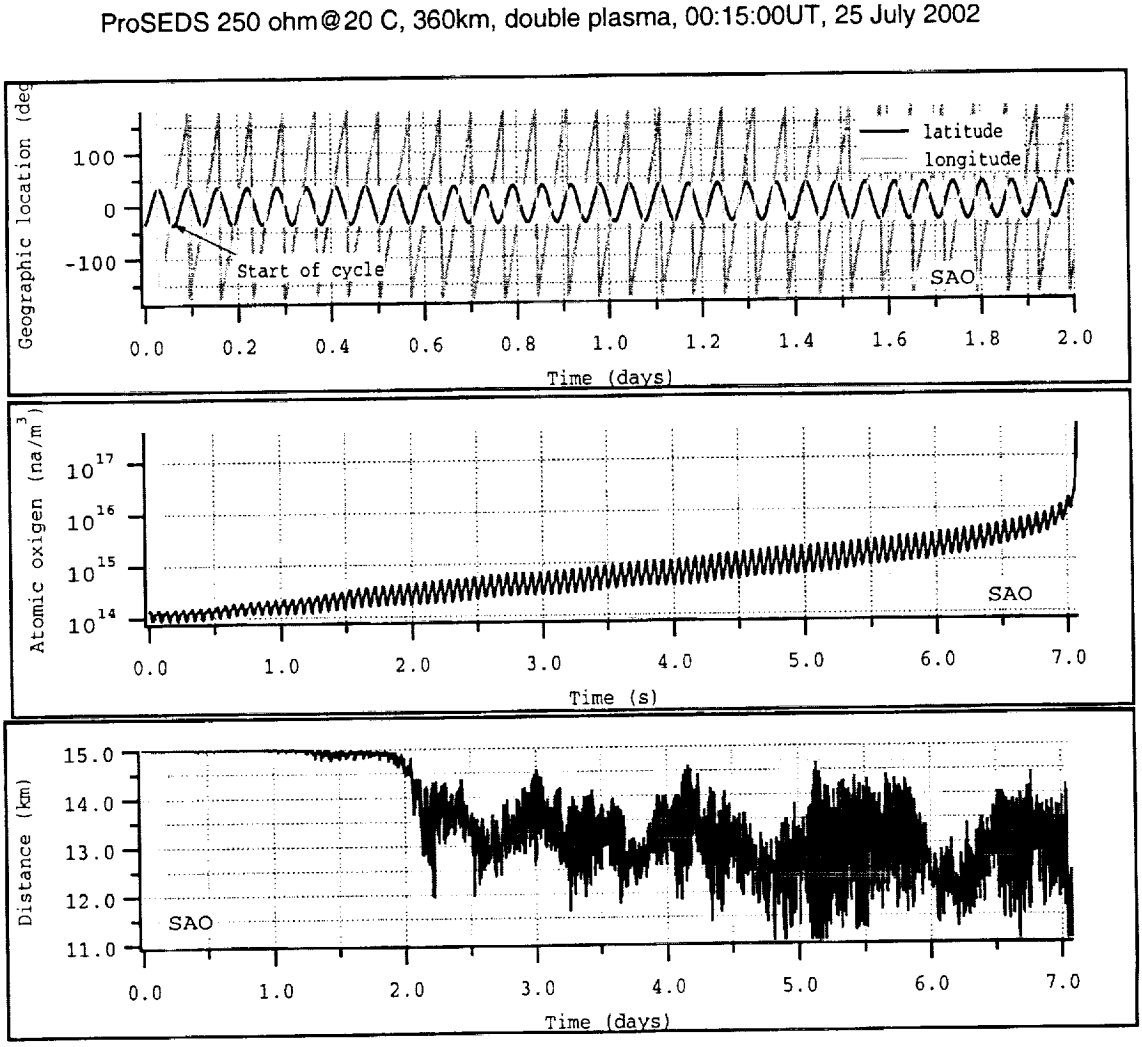


**Figure 15** Results for Summer 2002 launch, plasma density twice nominal

## 1.5 Concluding Remarks

The changes in the operating cycles and most notably the elimination of the open-circuit mode during the 80-s cycles have changed the decay rate and dynamic response of ProSEDS. The present estimates of the orbital decay rate for a launch on July 25$^{th}$, 2002 are 11 km/day while operating the 60-s cycle (for 5 orbits) and 19 km/day while operating the 80-s cycle during the remainder of the mission but before the neutral drag overpowers the electrodynamic drag. The decay rates estimates are valid with good approximation for any launch date during the Summer of 2002 because the estimated ionospheric and solar indexes that drive the plasma density vary only moderately over the three-month Summer period.

An extreme case with a plasma density twice as high as for nominal solar conditions was run to check the dynamical stability of the system. The decay rate increases only by 20% with respect to the nominal case thanks to the characteristic of the bare-wire anode to adjust to variations of the plasma density. The dynamics of the system remains stable.

## 2.0 EVALUATION OF POWER DELIVERED BY THE TETHER

### 2.1 Introduction

The elimination of the open-circuit mode in the 80-s operating cycle changes the amount of electrical energy available to recharge the battery. As a matter of fact, the change in the operating cycle increases the time spent in battery charging mode (i.e., mode 4) from the previous 35 s to 50 s per cycle. Moreover, the value of the tether resistance of the flight tether is lower (250 ohm at 20 °C) than the value of 265 ohm (at 20 °C) utilized in the previous estimates of the current produced by the tether. Consequently, a new estimate of the tether current during battery charging was carried out as shown in the following subsections.

### 2.2 Numerical Results

The estimate of the tether current produced during battery charging was computed for minimum solar activity conditions predicted for July 2002. The minimum solar conditions, corresponding to a 5% percentile probability, provide a conservative estimate of the tether current (and consequently power) available to recharge the secondary batteries. All other orbital and system parameters are the same of the reference mission described in Section 1.0 of this report. Figure 16 shows the instantaneous tether current during battery charging (mode 4) and the 12-hour running average of the current. The average is computed over the mode-4 period of 50 s and not over the overall cycle of 80 s.

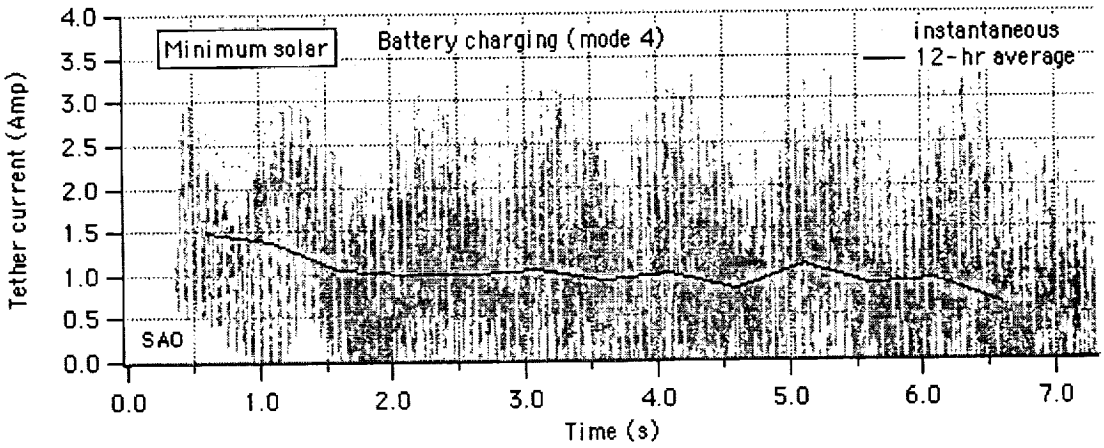


**Fig. 16** Tether current during battery charging mode: instant value and 12-hour average

The average value of the current is 1.33 Amp during the first day while the peak value of the current is 3.71 Amp. The corresponding values for nominal solar conditions (the plot is not shown) are 1.42 Amp for the average and 3.85 Amp for the peak value during the first day. The average value of the current decreases by roughly 30% after 1.5 day mostly due to tether dynamics.

Although the average values of the current during battery charging are similar to those computed for earlier launch dates, the net advantage of the new 80-s cycle is that the electrical energy provided by the tether (during normal battery charging operation) is higher because mode-4 is now 50-s long as opposed to 35 s for the older version of the cycle.

## 2.3 Concluding Remarks

The change in the 80-s operating cycle has improved the power budget for ProSEDS because of the longer time spent in battery-charging mode (mode 4). The estimate of the average current for the first day of operation in battery charging mode is 1.33 Amp for minimum solar conditions with the average computed over the 50-s battery charging mode. The estimated average value for nominal solar conditions is 1.42 Amp. The average values decrease by roughly 30% after 1.5 day due to system dynamics.

The value of the average current is similar to what was computed for the previous launch dates. However, the total electrical energy available for battery charging (during normal battery operation) is better than with the older 80-s cycle because the battery charging mode is now 50-s long as opposed to 35 s.

# 3.0 Updated Deployment Control Profiles and Simulations

## 3.1 Introduction

We recall here that the ProSEDS control law consists of three distinct modes of operations which are activated during the deployment of the three different tether sections. The non-conductive 10-km-long Dyneema tether is deployed according to the SEDS-II feedback-feed-forward control law. During the deployment of the 4.85-km conductive wire, the brake is simply kept at a constant, low value in order to limit the deployment velocity. During the deployment of the 215-m insulated tether section, the brake is commanded to follow a time-based profile to slow down the deployment velocity at the end of the tether.

As explained in details in the Annual Report #1, the control law utilizes a set of control parameters and a reference table that provides the feed forward information to the first portion of the control law. The reference table provides the control law with the nominal deployed length, speed (in terms of turn counts and turn count rate) and brake profiles that the system should follow under ideal conditions. The feedback, then, adjust the nominal fed forwarded brake profile based on the errors of the actual length and speed with respect to the nominal length and speed profiles.

The second and third portions (for the CCOR wire and insulated section deployment) are open-loop control. The second portion is a tension-offset control in which the brake is kept constant at a low value of turns simply for increasing the tether tension and reduce the maximum exit velocity. The wire is coated with a fairly delicate coating that can be rubbed off by excessive friction. Consequently, it is not possible to utilize a feedback control that ramps the brake up and down. The offset value of the brake utilized during this portion is a constant 0.5 brake turn for the flight control law.

In the third portion of the control law, the brake is made to follow an open loop rampup-constant-ramp down profile. This control law acts on the 215-m-long section of the tether with a quick ramp up phase. Because of the absence of a sensor that measure the exit velocity directly in the SEDS hardware, the velocity must be computed numerically from a noisy signal and then filtered to make it usable for a feedback control law. This process is actually used in the first portion of the control law where a delay in the computation of the velocity does not affect the performance of the controller. Due to the short reaction time available for the tether slow down, we opted for an open-loop control during this phase and we shaped the slow down profile in such a way that it is rather

tolerant of changes in the friction characteristics of the tether (see Annual Report #1 for more details).

### 3.2 Friction model

We rewrite in the following the frictional tension model (derived originally by J. Carroll, see also Ref. [7]) of the tether and its parameters for the reader's convenience:

$$T = \left(T_0 + I \cdot \rho \cdot \dot{L}^2 \cdot A_{rel}^E\right) \cdot k^{2\pi f n^{effe}} \cdot e^{f|\theta_0 - \theta|} \qquad (1)$$

In equation (1), the term in round parenthesis is the frictional model of the tether/deployer. The first exponential function with base $k$ is the model of the brake and the second exponential function with base $e$ is the model of the tether exit guide. The model parameters are:

| | |
|---|---|
| $A_{rel}$ | $= 1 - A_{sol} \cdot L / L_{fin}$ |
| $A_{sol}$ | = annulus solidity of tether |
| L | = length of tether deployed |
| $L_{fin}$ | = final length of tether |
| B | $= 2\pi f n$ ($n$ is the number of tether turns wrapped around the brake post) |
| $T_0$ | = minimum tension |
| $\rho$ | = linear density of tether |
| I | = inertia multiplier |
| $\dot{L}$ | = tether exit speed |
| $\vartheta$ | = tether's exit angle with respect to the local vertical |
| $\vartheta_0$ | = tether deployment null angle (orientation of the longitudinal axis of deployer with respect to the local vertical) |
| f | = friction coefficient |
| n | = number of brake turns |
| effe | = brake effectiveness coefficient |
| k | = base of the brake power law |

The updated values of the friction parameters obtained from the deployment tests on ground of the F-1 tether are as follows:

---

Date: 8 January 2002
From: E.C. Lorenzini (SAO)

Friction Parameters of the F1 flight tether

The reference values of the tension parameters for the ProSEDS tension model are as follows. These values are based on the deployment test (room temp.) of the F1 tether.

**Flat Dyneema (cleaned)**

| | | |
|---|---|---|
| $T_{min}$ | = spectra minimum tension | = 18 mN |
| den | = spectra linear density | = 0.2 kg/km |
| I | = inertia multiplier | = 2.0 |
| f | = spectra friction coeff | = 0.17 |
| E | = area exponent | = -0.4 |
| effe | = brake effectiveness $Turn^{effe}$ | = 1.2 |
| AnSol | = annulus solidity | = 0.2 (for $L_F$ = 10km) |
| k | = base of braking power law | = 1.7 |

**Wire (CCOR)**

| | | |
|---|---|---|
| $T_{min}$ | = wire minimum tension | = 75 mN |
| den | = wire linear density | = 1.935 kg/km |
| I | = inertia multiplier | = 1.7 |
| f | = friction coeff | = 0.19 |
| E | = area exponent | = -0.65 |
| effe | = brake effectiveness $Turn^{effe}$ | = 1.2 |
| AnSol | = annulus solidity | = 0.947 (from 1.25km -> 6.25km) |
| k | = base of braking power law | = 2.72 (= e) |

**Insulated (Kevlar overbraided)**

$T_{min}$ = insulated minimum tension = 300 mN

den = insulated linear density = 3.176 kg/km

f = friction coeff = 0.22

I = inertia multiplier = 1.7

E = area exponent = -0.65

effe = brake effectiveness $Turn^{effe}$ = 0.9

AnSol= annulus solidity = 0.947

k = base of braking power law = 2.72 (= e)

---

Subsequent tests of the F-1 run in hot and cold conditions validated most of the values of the friction parameters with the exception of the minimum tether tension which is more sensitive to temperature variations and even more importantly to the amount of residual sizing agent in the non-conductive tether (level of cleanliness). The flight tethers have all been cleaned in order to provide values of the minimum tension below 20 mN. However, the control law is tested (as shown later on) also for much higher values of the minimum tension. The typical range of variation of the non-conductive tether minimum tension is assumed conservatively to be in the range 5mN-30mN which are the limit values measured during the deployment tests of the many tethers developed for ProSEDS (and not just the F-1).

The friction parameters of the whole tether (with the three different sections) are utilized to derive the reference table, that is, the reference deployment profile and a brake profile for the whole tether. The brake actuation is then adjusted by the feedback control law during the deployment of 10-km Dyneema portion while the reference brake profile is followed (without adjustments) during the wire and insulated portions of the tether.

### 3.3 Flight reference table

Several new reference tables were derived for the deployment control law as tether friction data became available during the year from the deployment tests and spooling data from Tether Applications, Inc. We will not describe here all the new updates but rather concentrate on the flight reference profile (Reference #78).

The process for deriving the reference profile is an optimization process that aims at minimizing a cost function which encapsulates the departure of the final dynamic state from the desired state. The desired final state at the end of deployment is for the system to be aligned and swing less with respect to the local vertical with a residual longitudinal velocity greater than 3 m/s before the beginning of the insulated portion of the wire (last 215 m of tether). The residual velocity is then reduced by a final activation of the brake immediately after the exiting of the insulated wire is sensed. The process for deriving the reference profile is described in more detail in the Annual Report #2.

The flight reference table was derived based on the friction data of the F-1 tether deployment test at room temperature and for a minimum tether tension equal to 20 mN. This minimum tension is slightly higher than the 18 mN measured in that deployment test but the 20 mN value provided a reference profile with better features (e.g., smoothness of the deployment velocity and progressive ramping up of the brake) than what could be obtained with the 18 mN value. The friction data from the room temperature test were preferred to the hot and cold test data because the deployer will be close to room temperature at the start of deployment.

The most recent parameters adopted for deriving the flight reference profiles are as follows

*Orbital and ejection parameters*

Orbit: 360x360 km

Orbital inclination: 36 deg

Ejection velocity = 2.74 m/s

Ejection angle = 5 deg (forward of LV with an upward deployment)

*System parameters*

Satellite mass = 21.4 kg

Delta-II Mass = 994 kg

Tether lengths: 10132 m Dyneema, 4865 m CCOR and 215-m insulated

Tether length is then converted to tether turns (and velocity to turn rate) which are the variable utilized by the control law. Consequently, two tethers appear very similar to the control law if the number of turns of the three segments are about the same. The following files (supplied by J. Carroll, Tether Applications, Inc.) provide the spooling data for the F-2 and F-3 tethers, respectively

## F-2 flight tether spooling

Tether Applications, Inc.

Here are the quadratic equations for the Kevlar+Dyneema, CCOR, and overbraided insulated wire. The values are derived from the turns and estimated as-deployed lengths at various points in the winding, including the estimated effects of Dyneema creep during bakeout, and the temperature and tension differences between winding and deployed conditions. (The deployed tension is assumed to be ~1.3 newtons.) The "L" in meters and "T" (in core turns) for each segment start at zero when that segment starts deploying.

Quadratic length formula for PROSED19 winding of F-2 tether:

```
Noncond: 10132 meters; 14733 turns;  L = 0.72822 * T - 2.75E-6 * Sqr(T)
C-COR:    4865 meters; 11037 turns;  L = 0.64497 * T - 18.5E-6 * Sqr(T)
Insul:     215 meters;  1108 turns;  L = 0.2339  * T - 36E-6   * Sqr(T).
```

The F-2 non-conductive tether is 5 turns & 92 meters longer than F-1.
The F-2 wire is 138 turns shorter but 12 meters longer than F-1.
Most of these differences are due to the increased bulk of the longer overbraid on F-2, and the fact that we needed about the same wire length but the same # of Dyneema turns.

| Meters | Turn# | Transition |
|---|---|---|
| 0 | 0 | Outer Kevlar tie-down |
| 20 | 28 | End of Kevlar leader (start of Dyneema) |
| 5562 | 7872 | Near the middle of the Dyneema |
| 10132 | 14733 | Start of wire (end of Dyneema) |
| 12705 | 19328 | Near the middle of the wire |
| 14334 | 23384 | Parallel/criss-cross winding transition |
| 14997 | 25770 | Start of overbraided insulated wire |
| 15012 | 25835 | Brake turn (second of two to deploy) |
| 15212 | 26878 | Termination pin at base of core |

F-2 cross-straps and key transitions (m) from inner termination pin:

| Meters | CoreTurn | Feature |
|---|---|---|
| 0 | 0 | Termination pin at base of deployer |
| 200 | 1043 | Brake enable sensor hole |
| 215 | 1108 | End of overbraided insulated length. |
| 257 | 1287 | 1 (inboard cross-strap; rest are spaced 321m apart) |
| 578 | 2507 | 2 |
| 900 | 3559 | 3 |
| 1221 | 4484 | 4 |
| 1542 | 5331 | 5 |
| 1863 | 6119 | 6 |
| 2184 | 6853 | 7 |
| 2505 | 7547 | 8 |
| 2826 | 8206 | 9 |
| 3147 | 8835 | 10 |
| 3469 | 9438 | 11 |
| 3790 | 10015 | 12 |
| 4111 | 10572 | 13 |
| 4432 | 11110 | 14 |
| 4753 | 11631 | 15 |
| 5074 | 12136 | 16 (outboard cross-strap) |
| 5080 | 12145 | End of wire (7 wires tuck into core, 1" apart) |

## F-3 flight tether spooling data

End-to-End Description of Flight Winding of F-3 (PROSED21)

Joe Carroll
Tether Applications, Inc.
Winding dates: March 18-19, 2002
Post-wind handling finished March 21, 2002

Notes on winding:

F-3 quadratic length formulas (winding PROSED21):
Non-conduct: 10167 meters; 14730 turns; L = 0.73029*T - 2.72E-6*Sqr(T)
C-COR wire: 4870 meters; 11042 turns; L = 0.64642*T - 18.6E-6*Sqr(T)
Insul wire: 214 meters; 1103 turns; L = 0.2337*T - 36E-6*Sqr(T).

For comparison, here are the formulas for F-2 and F-1:

F-2 quadratic length formulas (winding PROSED19):
Non-conduct: 10132 meters; 14733 turns; L = 0.72822*T - 2.75E-6*Sqr(T)
C-COR wire: 4865 meters; 11037 turns; L = 0.64497*T - 18.5E-6*Sqr(T)
Insul wire: 215 meters; 1108 turns; L = 0.2339*T - 36E-6*Sqr(T).

F-1 quadratic length formulas (for first winding, PROSED15):
Non-conduct: 10040 meters; 14728 turns; L = 0.7215*T - 2.70E-6*Sqr(T)
C-COR wire: 4894 meters; 11350 turns; L = 0.6378*T - 18.2E-6*Sqr(T)
Insul wire: 174 meters; 933 turns; L = 0.2201*T - 36E-6*Sqr(T).

Tether mass/length:
Kevlar: 2.10g/m
Dyneema: 0.150g/m
CCOR: 1.92g/m
InsWire: 3.25g/m

Transition locations for F-3 (PROSED21):

| As wound: MetW | As wound: Core | As deployed: Meters | As deployed: Turn# | Transition |
|---|---|---|---|---|
| 30917 | 26875 | 0 | 0 | Outer Kevlar tie-down |
| 30878 | 26849 | 19 | 26 | End of Kevlar leader (start of Dyneema) |
| 19596 | 19008 | 5577 | 7867 | Stop mid-Dyneema (0.2% longer in orbit) |
| 10278 | 12145 | 10167 | 14730 | Start of wire (end of Dyneema) |
| 5072 | 7556 | 12741 | 19319 | Stop mid-wire (wire=0.07% shorter) |
| 1777 | 3497 | 14371 | 23378 | Parallel/criss-cross transition |
| 430 | 1103 | 15037 | 25772 | End of overbraid wrap-splice |
| 402 | 1044 | 15051 | 25831 | Brake turn (second of two to deploy) |
| 0 | 0 | 15251 | 26875 | Termination pin at base of core |

Turn differences of F-2 (PROSED19) and F-1 (PROSED15 & PROSED18) from F-3:

| F-2 | F-1#1 | F-1#3 | Transition |
|---|---|---|---|
| +3 | -2 | +76 | Start of wire (end of Dyneema) |
| +6 | -233 | -154 | Parallel/criss-cross transition |
| -2 | +306 | +453 | End of overbraid wrap-splice |
| +4 | +102 | +228 | Brake turn (second of two to deploy) |
| +3 | +136 | +272 | Termination pin at base of core |

Basis of length estimates:
Estimated as-deployed length per turn of TAI metwheel (491.066mm/turn w/o tether) 496.5 mm for insulated overbraided tether & 20m Kevlar leader (same as as-wound) 494.5 mm for C-COR-coated conductive tether (this is 0.07% shorter than as-wound) 492.6 mm for flat 13x100 Dyneema braid (this is 0.2% longer than as-wound)
Winding temperature range: ~21-23C
Winding tension (lengths were measured at these tensions):
13-16 newtons for parallel winding
12, 10.5, 9, 7.5, and 10 newtons for CC patterns #1-5.

Explanation of adjustments from as-wound to as-deployed conditions:
Assume Dyneema creep during bakeout reduces its tension to as-deployed tension.
Assume Kevlar has equilibrium post-deployment tension of ~1.3 newtons
Modulus of long segments (C-COR and Dyneema) is ~12000-15000 newtons.
Assume Dyneema and CCOR are 225K and 300K in orbit; CTEs are -28ppm/K and 0ppm/K. Thus Dyneema should be ~0.2% longer; CCOR ~0.07% shorter, deployed vs. wound.

F-3 Cross-strap locations (from start of winding):

| MetWhl | CoreTurn | Meters | Gap |
|---|---|---|---|
| 530W | 1311.1C | 262 | 262 |
| 1179W | 2524.4C | 584 | 321 |
| 1828W | 3572.4C | 905 | 321 |
| 2477W | 4495.5C | 1226 | 321 |
| 3127W | 5343.7C | 1547 | 322 |
| 3777W | 6131.4C | 1869 | 321 |
| 4426W | 6866.1C | 2190 | 321 |
| 5076W | 7559.4C | 2511 | 321 |
| 5725W | 8217.9C | 2832 | 321 |
| 6373W | 8846.7C | 3153 | 321 |
| 7023W | 9447.5C | 3474 | 321 |
| 7672W | 10024.0C | 3795 | 321 |
| 8322W | 10578.9C | 4116 | 321 |
| 8970W | 11115.3C | 4437 | 321 |
| 9619W | 11633.7C | 4758 | 321 |
| 10267W | 12136.6C | 5078 | 320 |

The differences in turns of the F-2 from the F-3 are less than 6 turns which makes them almost perfectly alike to the control law. The reference profile (Ref. #78) works equally well for the F-2 and F-3 flight tethers. This reference profile, shown in Figure 17, has several good features as follows: (a) the exit velocity changes smoothly during the Dyneema deployment and it does not deep down to low values; (b) the brake increases monotonously from zero to its maximum value; and (c) the libration angle is very close to zero at the end of deployment (for reference conditions). This reference profile when combined with the control law provides a final libration amplitude which is quite insensitive to variation of the Dyneema minimum tension and other friction parameters as it will be shown later on. The reference table for Ref. #78 is tabulated in Appendix A.

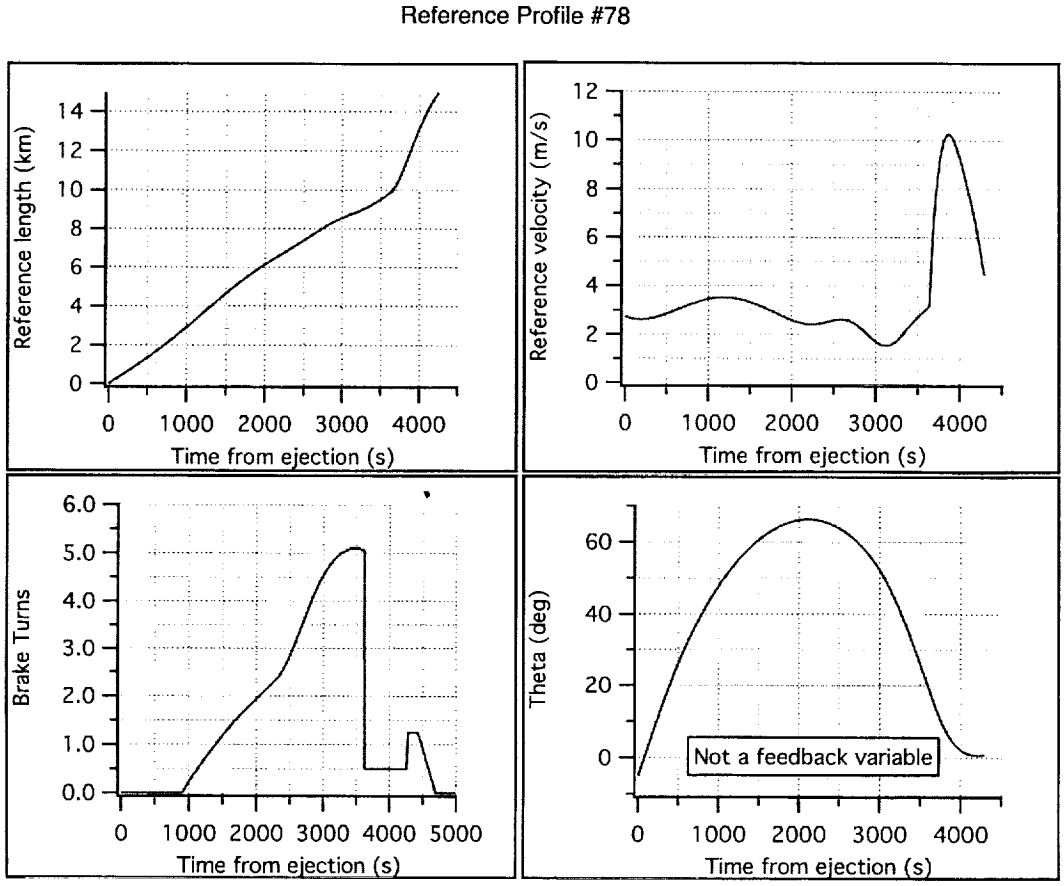


**Figure 17** Control law Reference Profile #78

### 3.4 Flight control law parameters

The control law not only provides the logic for controlling deployment under perfect functionality of the sensors. It also has a set of backup modes to circumvent or mitigate the effects of possible failures or malfunctions of the deployer sensors. The sensors in question are the two turn counters (Counter-A and Counter-B) which measure the number of tether turns that have been deployed. In standard operation, the output of the two turn counters is combined to produce a software turn count Counter-C which is unaffected by double counts. In case of failure of one of the turn counter, Counter-C is bypassed and the still functioning turn counter is utilized by the sensor logic. However, when only one turn counter is working there is an over count of the number of turns that has to be accounted for by the control law when transitioning from one tether segment to the next. Also, if both turn

counters fail, the control law logic sets the feedback to zero and utilizes exclusively the reference profile to drive deployment (this is one additional advantage of having the feed-forward profile in the control law). Similarly, there are two levels of backup for the actuation of the slow down maneuver that starts at the beginning of the insulated tether portion (last 215 m of tether). The slow down maneuver is activated, in standard operation, by the turn counter. In case of the two turn counters failing, there are two level of backup as follows: the first one is provided by the brake enabler switch which senses the beginning of the insulated wire and the second is provided by time.

The control parameters define the standard operation of the control law and also the activation of the backup modes. The parameters controlling the standard operation are taken from the SEDS-II control set with a few adjustments aimed at improving the robustness of the control law to variations of the friction parameters. The control parameters that define the control modes corresponding to transitions from one tether segment to the next and the parameters that define the backup modes have been added to the original control set of the SEDS-II control law. The complete set of the updated control parameters for Reference #78 are shown in Table 1.

**Table 1** Updated control parameters for Reference #78

Values of control parameters for ProSEDS Ref#78 (F2 & F3 tethers). Issued on April 5, 2002; revised on July 23, 2002.

---------- CONTROL PARAMETERS (REF. #78) ----------

| No. | PARAMETER | VALUE | (Units) | Type |
|---|---|---|---|---|
| 1. | c | 0.125 | | Filter coefficient |
| 2. | GTC | 0.002 | (1/turn) | TurnCount Gain |
| 3. | DZTC | 5 | (turn) | TurnCount Deadzone |
| 4. | TCELIM | 3000 | (turn) | Max. TurnCount Error |
| 5. | GTCR | 0.4 | (s/turn) | TurnCountRate Gain |
| 6. | DZTCR | 0.1 | (turn/s) | TurnCountRate Deadzone |
| 7. | TCRELIM | 5 | (turn/s) | Max. TurnCountRate Error |
| 8. | WAILP | 3 | | WrapIncrement UpperLimit |
| 9. | TBD s | 65535 | (sec) | Time after which BIAS is applied |
| 10. | BIAS | 0 | (turn) | BrakePost Bias |
| 11. | WACLP | 6.5 | (turn) | WrapAdjustment UpperLimit |
| 12. | TCBS | 18000 | (turn) | Turns Count Brake Stop (SEDS-II law) |
| 13. | A1 | 0.724 | | Coeff_1 in Variable Gains |
| 14. | A2 | 2.82E-6 | | Coeff_2 in Variable Gains |
| 15. | STOPDEPLOY | 65535 | (sec) | Time for brake ramping up to max. value at end of deployment (SEDS-II law) |
| 16. | TCDUTY | 13560 | (turn) | End of 50% duty cycle |
| 17. | TURNBRAKE0 | 14265 | (turn) | RampDown brake to WIREBRAKE |
| 18. | WIREBRAKE | 0.5 | (turn) | BrakeTurns during CCOR deployment |
| 19. | RAMPUP | 25835 | (turn) | Start of slowdown procedure |

| | | | |
|---|---|---|---|
| 20. QUITLAWBACKUP | 14400 | (turn) | Ramp down brake in case of CounterA or B failure |
| 21. BRSD | 1.25 | (turn) | Max brake turns during slow down |
| 22. TBD(15) | 20 | (sec) | Time to rampup brake from WIREBRAKE to BRSD |
| 23. TIMECFAIL | 120 | (sec) | Time of no update of CounterC to declare the CounterC failed |
| 24. TIMEDUTY | 6080* | (sec) | Time-based equivalent of TCDUTY |
| 25. TIMEQUERY | 6832* | (sec) | The software starts interrogating the BES if CounterC has failed |
| 26. TIMERAMPNOBES | 6894* | (sec) | Time-based start of slowdown procedure if the BES was declared failed |

*These values of parameters assume a SMET = 2640 sec at endmass separation (parameters revised on July 23, 2002)

Notes:
BES = brake enable switch
SW = flight software
SMET = secondary mission elapsed time

### 3.5 Sensitivity of control law to friction parameters

Deployment trajectory is mostly influenced by the tether tension profile during the early part of deployment (see Ref. [8]). The physical explanation for this behavior is that small changes in the tether changes alter the dynamics the most when the external forces (i.e., the gravity gradient) are small, that is, at short tether lengths.

The deployment test data show that the range of variation of most of the friction parameters are smaller than ±20%. The minimum tether tensions of the Dyneema and the CCOR wire are the exception. The value of the Dyneema minimum tension in particular changes by a few folds across the many tether samples tested. The CCOR minimum

tension, besides being less variable than the Dyneema, has an almost negligible effect on the libration amplitude at the end of deployment.

The minimum tension of the ProSEDS Dyneema tether (which dominates the final state at the end of deployment) has already been measured in deployment ground tests under different temperatures to vary between 5mN and 30 mN for all the tether samples tested with a smaller range of variation for the F-1 tether. Consequently, the control law must provide a residual libration at the end of deployment of less than 20° (as specified by the mission requirements) within the measured range of variability of the minimum tension.

The control law with Ref. #78 can tolerate without a significant decay in performance a value of the non-conductive tether minimum tension between 5 mN and 30 mN. For 30 mN $< T_0 <$ 60 mN, the libration at end of deployment increases above 10° but still below 20°. For $T_0 \geq$ 80 mN, the deployment stops at a distance of about 500 m because of excessive friction and without any role being played by the control law. The critical value of 80 mN for the minimum tension is determined by the ejection velocity which with the present ejection system is equal to 2.74 m/s.

Figure 18-20 show details of the deployment dynamics for values of the minimum Dyneema tension for $T_0$ = 5 mN, 10 mN, and 20 mN (reference value), respectively. Figure 21 shows the effect on the control law and deployment dynamics of a noisy tether tension on the deployment dynamics (for $T_0$ = 20 mN). A ±50% white noise has been added to the tether tension. The figure shows that the control law is capable of handling the high noise level with ease. The brake actuation is still smooth and the deployment dynamics is negligibly affected by the noise. The final libration amplitude is unaffected by the white noise.

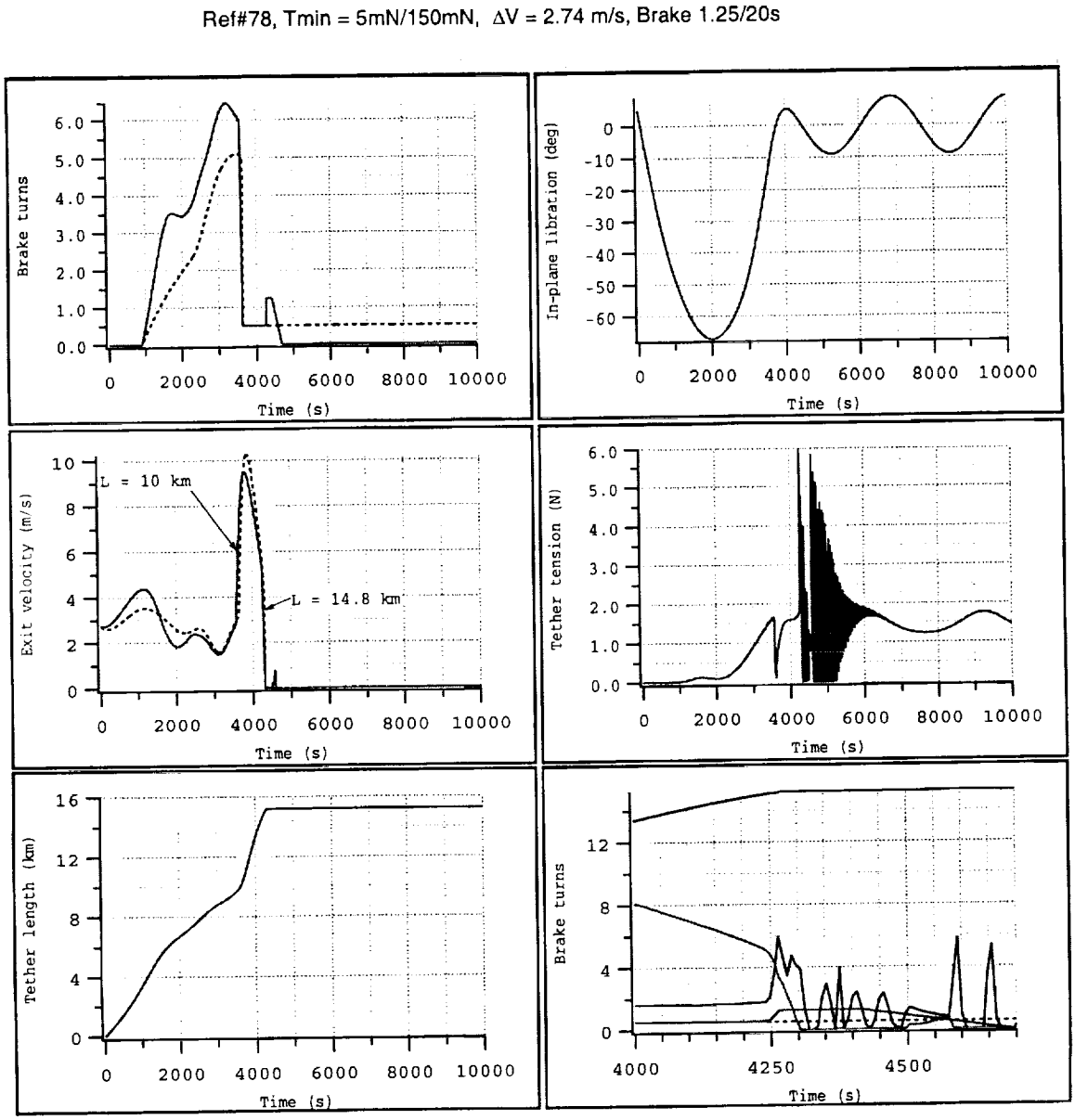


**Figure 18** Deployment dynamics for Ref#78 and $T_0$ = 5 mN

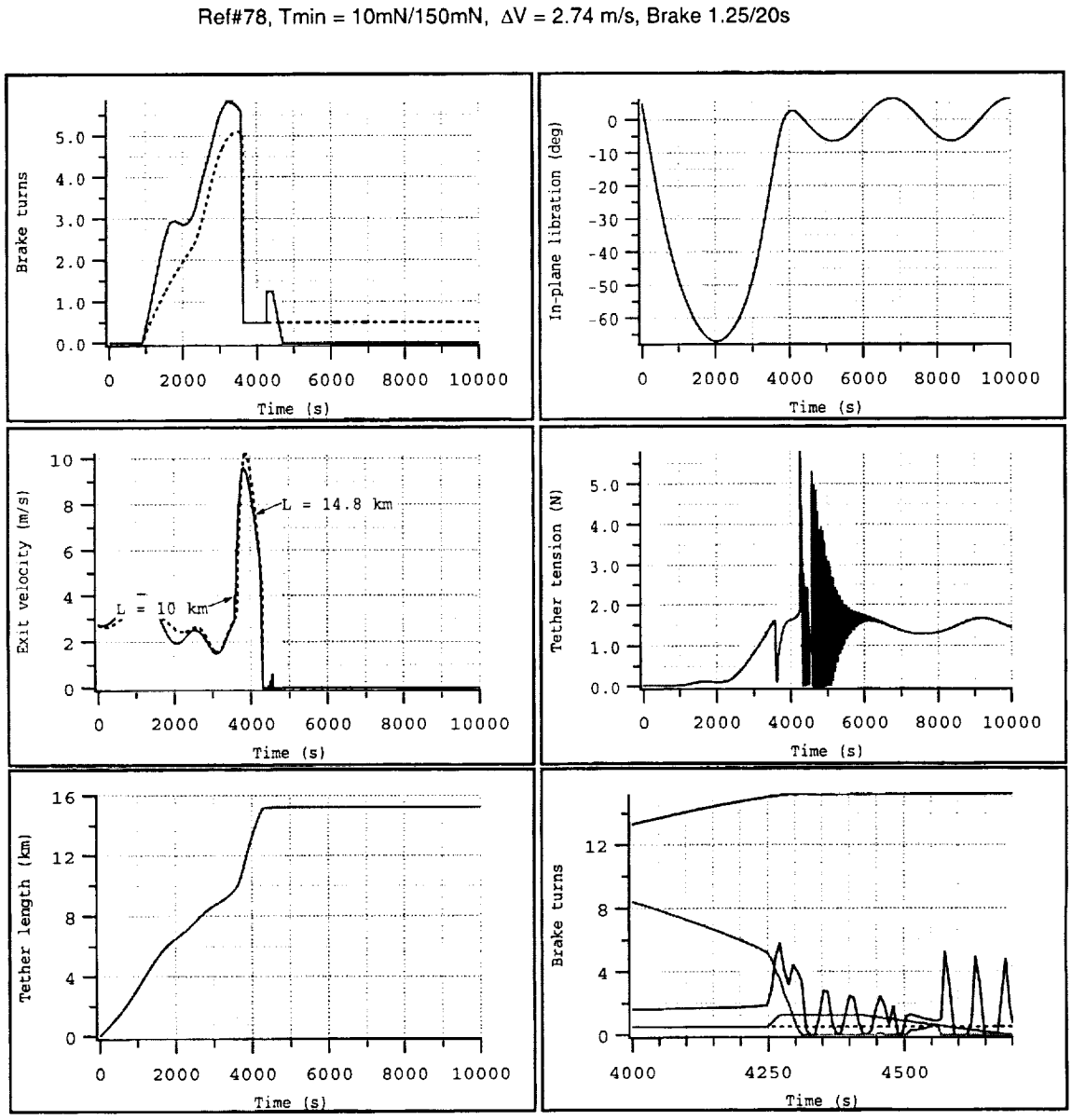


**Figure 19** Deployment dynamics for Ref#78 and $T_0$ = 10 mN

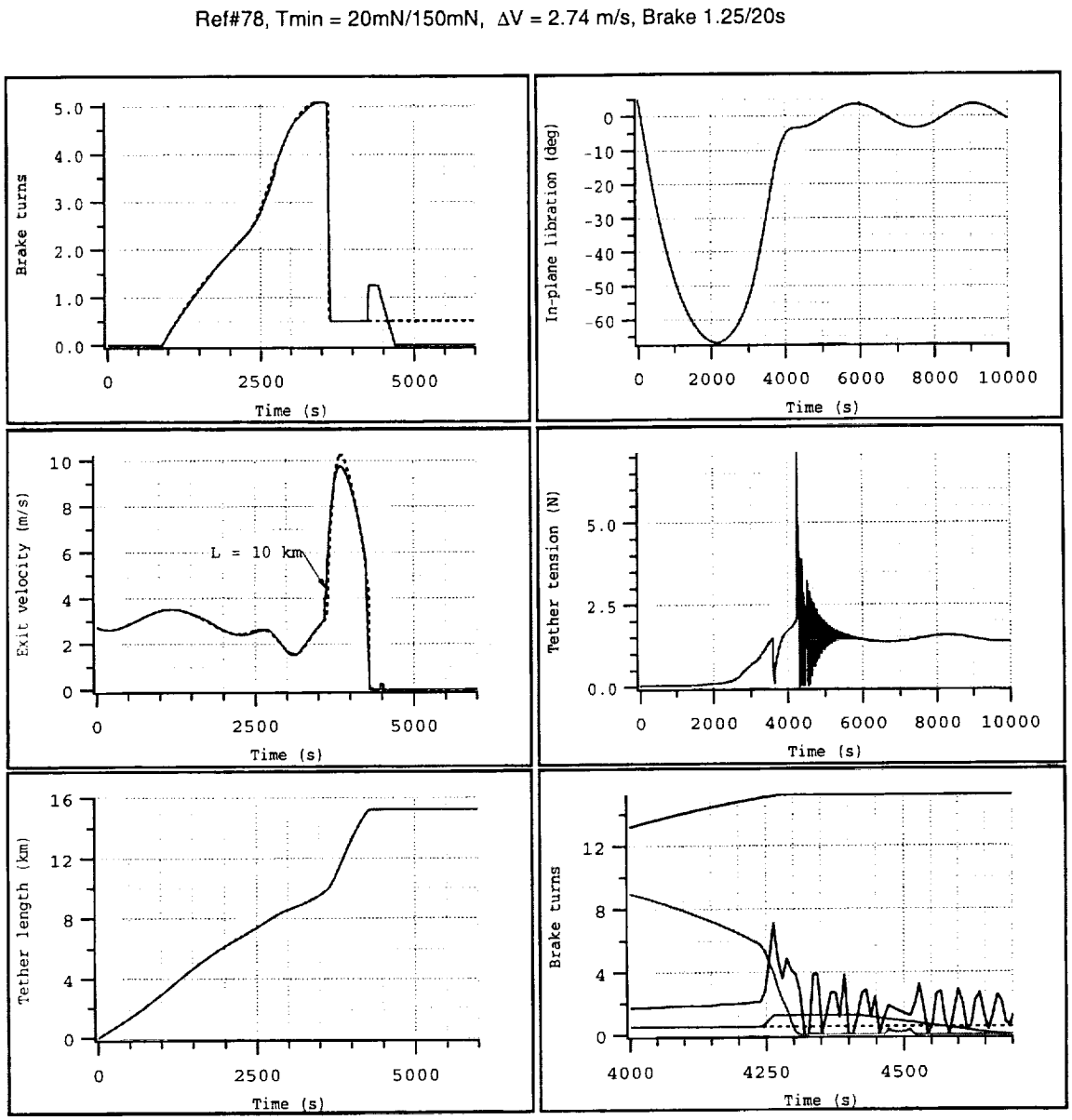


**Figure 20** Deployment dynamics for Ref#78 and $T_0$ = 20 mN (reference)

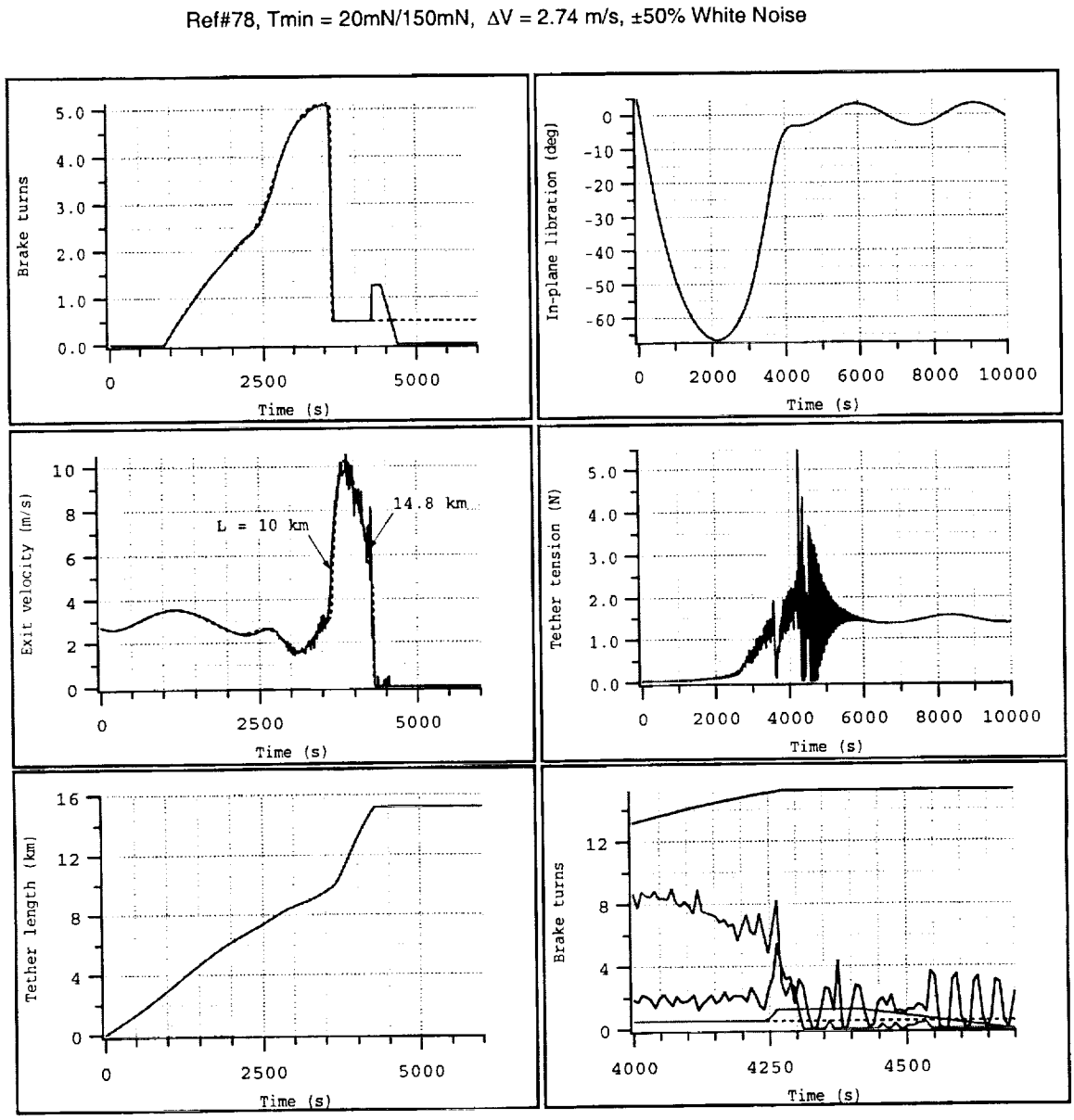


**Figure 21** Deployment dynamics for $T_0$ = 20 mN with ±50% *tension white noise*

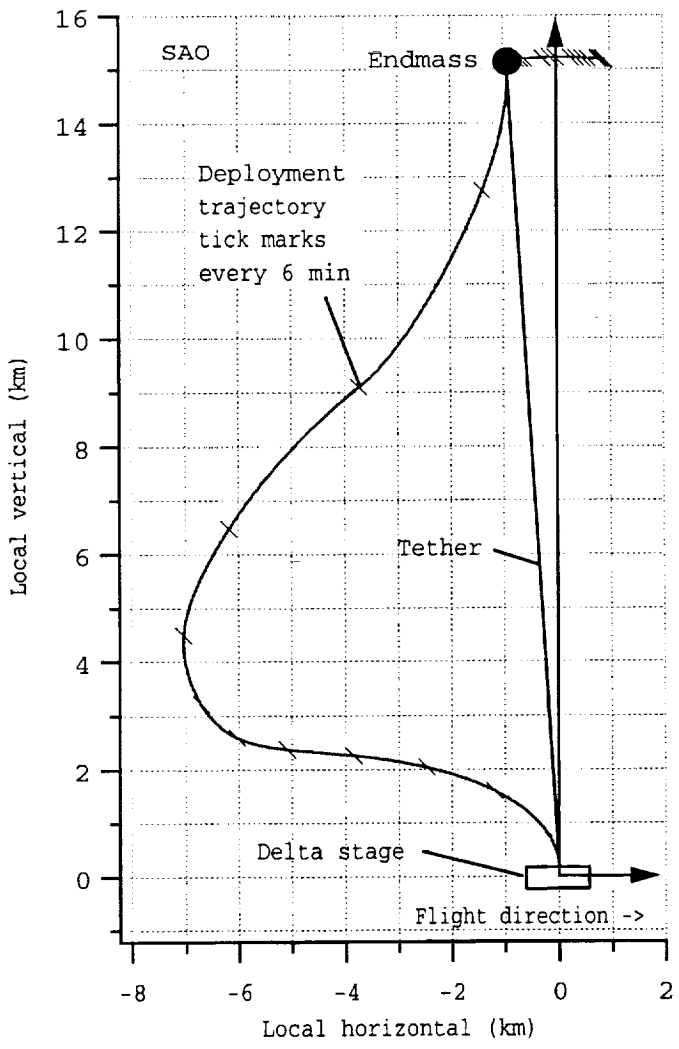


**Figure 22** Deployment trajectory of the endmass with respect to the Delta stage

Figure 22 depicts the deployment trajectory of the endmass with respect to the Delta stage for the reference case of $T_0 = 20$ mN. The tick marks along the trajectory are every 6 minutes and the CCOR wire starts deploying at about the point where the tick mark caption is pointing. Figure 23 shows the amplitude of the residual libration at the end of deployment vs. the minimum tension $T_0$ of the Dyneema tether for Ref. #78. The figure also shows the libration amplitude without deployment control and the representative points of the SEDS-I and SEDS-II missions. The final libration amplitude is sensitive to the Dyneema tether $T_0$ and it is quite insensitive to the value of the wire minimum tension $T_{wire}$. Values of $T_{wire}$ of 50-300 mN have been explored with very good deployment dynamics. Values as high as 500 mN are tolerable for the minimum tension of the wire.

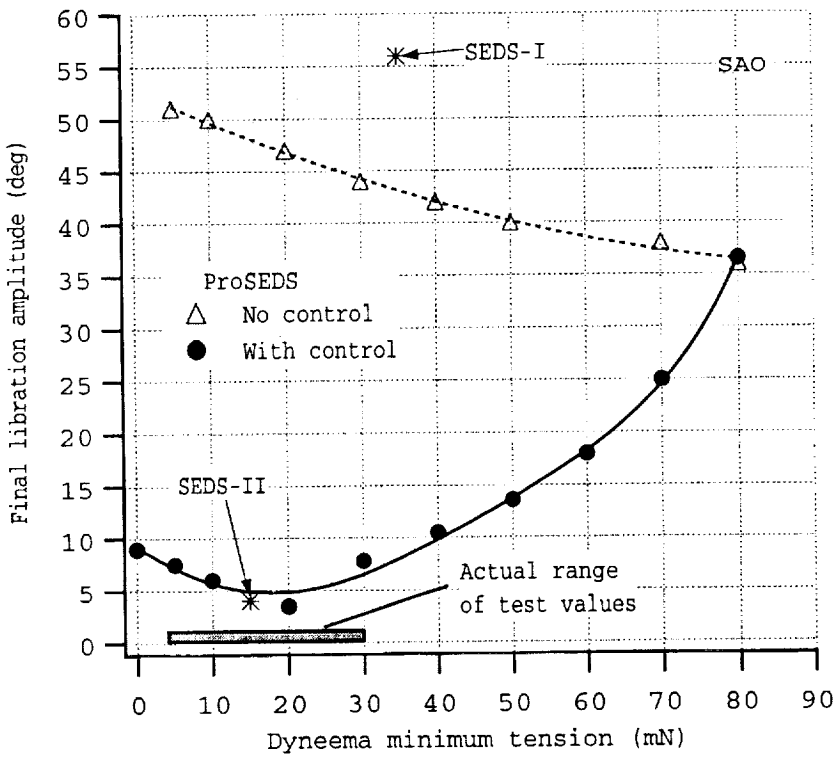


**Figure 23** Final libration amplitude vs. $T_0$ with control (Ref. #78) and without control

## 3.6 Concluding remarks

The deployment control law in combination with Reference Profile #78 is robust with respect to changes of the most influential and uncertain friction parameters. A number of backup modes have been built into the control logic to circumvent (or mitigate) the effects of the possible failure of one (or two) turn counters. The control law meets the requirement of a final libration smaller than 20° over the measured values of the friction parameters with a positive safety margin.

# 4.0 ANALYSIS/ESTIMATION OF DEPLOYMENT FLIGHT DATA

## 4.1 Introduction

The performance of the deployment control law in terms of final libration (and other dynamic variables) can be assessed from the single data stream of the turn counter. In fact, from the (in-plane) libration equation it is possible to see that in the absence of strong external forces (other than gravity gradient forces) the libration state of the system can be extracted from the knowledge of the tether length and speed profiles. Since deployment takes place almost exclusively on the orbital plane, knowledge of the in-plane angle define the libration state of the system.

It is possible to construct an observer of the system libration based on the deployed tether length and exit speed. In the actual case, the only available information is the turn counter which provides the number of deployed tether turns. The tether turns must be first converted into tether length by utilizing the spooling relationship. The length data must be filtered with a low-pass filter before computing the exit speed because any small jump in tether length over a short time period will result in a big jump of tether rate when the speed is computed by numerical derivation.

Finally, the smoothed length and speed can be used as input to the deployment observer in order to compute tether libration and consequently reconstruct the deployment trajectory of the endmass and estimate the libration amplitude after the end of deployment when the attitude of the endmass has stabilized.

An alternative way to the deployment state estimation is to utilize position estimates from the GPS receivers on board the endmass and the Delta and derive the relative dynamics through differences of simultaneous position data. The GPS-method, however, is predicated on having the two signals available from the very beginning of deployment when the endmass is tumbling and prone to loosing the signal lock. The GPS method, which will be implemented later on, could be utilized more reliably to backup the estimate of the libration amplitude at the end of deployment.

## 4.2 Numerical results

In the following we will show results from the deployment observer (i.e., based on the turn counter estimation method). We take a noisy string of turn counter data from the deployment simulation shown in Fig. 21 (with $T_0$ = 20 mN and heavy white noise) and we prove that the deployment trajectory can be reconstructed and the amplitude of the final libration accurately evaluated by means of the process described previously.

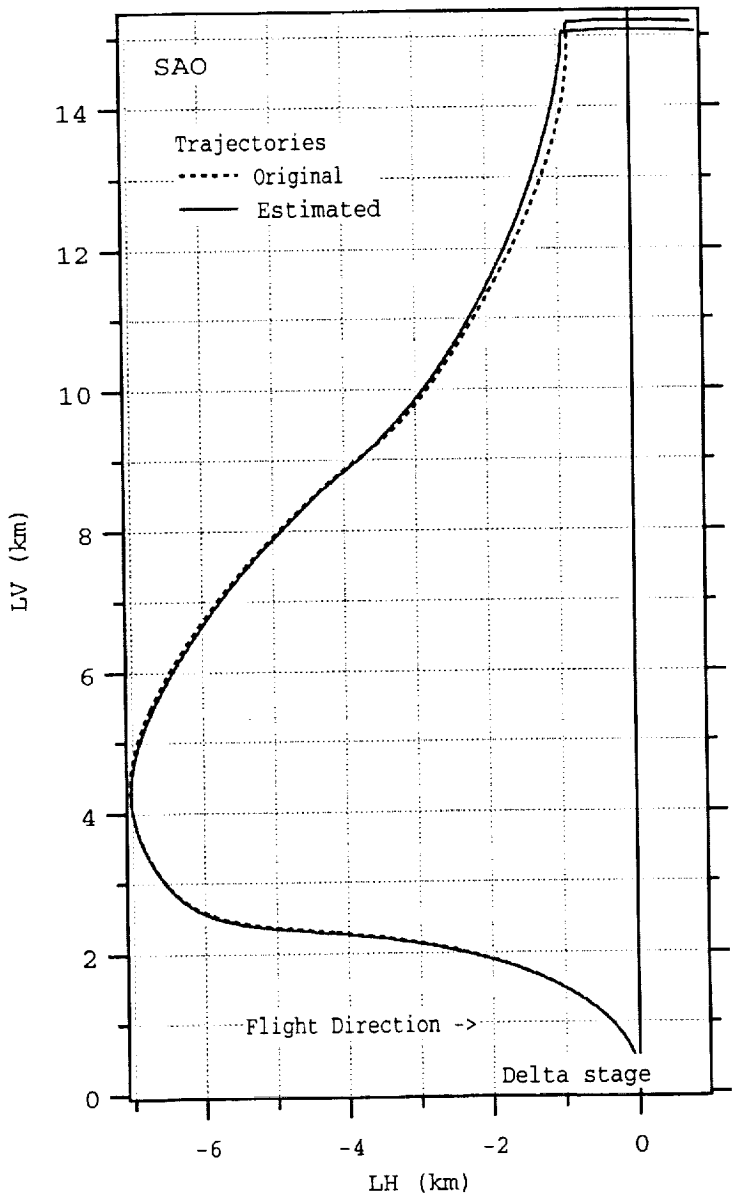


**Figure 24** Deployment trajectory of endmass: estimated from noisy turn counter data (solid line); and original data (dotted line)

Figure 24 shows the deployment trajectory of the endmass with respect to the Delta stage estimated from noisy turn counter data (for $T_0$ = 20 mN) and the original trajectory computed from the simulated data shown in Fig. 21. Clearly, the estimation software is capable of extracting the deployment trajectory from noisy turn counter data and of estimating accurately the libration amplitude at the end of deployment. This estimation software was also installed on the computer at NASA MSFC and it was run successfully twice during the mission operation simulations at the EDAC.

## 4.3 Concluding remarks

The estimation technique based on the data string provided by the turn counter is able to reconstruct the deployment trajectory and provide an accurate estimate of the amplitude of the libration at the end of deployment starting from noisy data. The advantage of this method is that it is based on one string of data that is readily available throughout deployment. The GPS data from both the Delta stage and the endmass can also be utilized to check the estimate of the libration after the end of deployment.

## APPENDIX A

Reference Table for ProSEDS deployment control law (Ref#78, flight). For completeness, this file includes data of tether length and tether exit velocity

Date: April 4, 2002
Author: E.C. Lorenzini (SAO)

Support File for ProSEDS Reference #78.

| Time (s) | Length (m) | Speed (m/s) | Turn (turn) | Turnrate (turn/s) | Brake (turn) |
|---|---|---|---|---|---|
| 0 | 0.5 | 2.74 | 1 | 3.752 | 0 |
| 8 | 22.378 | 2.73 | 31 | 3.739 | 0 |
| 16 | 44.173 | 2.719 | 61 | 3.726 | 0 |
| 24 | 65.889 | 2.71 | 90 | 3.714 | 0 |
| 32 | 87.53 | 2.701 | 120 | 3.703 | 0 |
| 40 | 109.101 | 2.692 | 150 | 3.692 | 0 |
| 48 | 130.605 | 2.684 | 179 | 3.681 | 0 |
| 56 | 152.044 | 2.676 | 208 | 3.672 | 0 |
| 64 | 173.424 | 2.669 | 238 | 3.663 | 0 |
| 72 | 194.749 | 2.662 | 267 | 3.654 | 0 |
| 80 | 216.021 | 2.656 | 296 | 3.647 | 0 |
| 88 | 237.245 | 2.65 | 325 | 3.64 | 0 |
| 96 | 258.424 | 2.645 | 354 | 3.633 | 0 |
| 104 | 279.561 | 2.64 | 384 | 3.627 | 0 |
| 112 | 300.662 | 2.635 | 413 | 3.622 | 0 |
| 120 | 321.729 | 2.631 | 441 | 3.618 | 0 |
| 128 | 342.765 | 2.628 | 470 | 3.614 | 0 |
| 136 | 363.775 | 2.625 | 499 | 3.61 | 0 |
| 144 | 384.761 | 2.622 | 528 | 3.608 | 0 |
| 152 | 405.728 | 2.62 | 557 | 3.605 | 0 |
| 160 | 426.679 | 2.618 | 586 | 3.604 | 0 |
| 168 | 447.617 | 2.617 | 615 | 3.603 | 0 |
| 176 | 468.545 | 2.616 | 643 | 3.602 | 0 |
| 184 | 489.467 | 2.615 | 672 | 3.602 | 0 |
| 192 | 510.386 | 2.615 | 701 | 3.603 | 0 |
| 200 | 531.306 | 2.615 | 730 | 3.604 | 0 |
| 208 | 552.229 | 2.616 | 759 | 3.606 | 0 |
| 216 | 573.159 | 2.617 | 788 | 3.609 | 0 |
| 224 | 594.098 | 2.618 | 817 | 3.611 | 0 |
| 232 | 615.05 | 2.62 | 845 | 3.615 | 0 |
| 240 | 636.019 | 2.622 | 874 | 3.619 | 0 |
| 248 | 657.005 | 2.625 | 903 | 3.623 | 0 |
| 256 | 678.014 | 2.628 | 932 | 3.628 | 0 |
| 264 | 699.046 | 2.631 | 961 | 3.633 | 0 |
| 272 | 720.106 | 2.634 | 990 | 3.639 | 0 |
| 280 | 741.196 | 2.638 | 1020 | 3.645 | 0 |
| 288 | 762.318 | 2.642 | 1049 | 3.652 | 0 |
| 296 | 783.475 | 2.647 | 1078 | 3.659 | 0 |
| 304 | 804.67 | 2.652 | 1107 | 3.667 | 0 |
| 312 | 825.904 | 2.657 | 1137 | 3.675 | 0 |

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|---|---|---|---|---|---|
| 320 | 847.182 | 2.662 | 1166 | 3.684 | 0 |
| 328 | 868.504 | 2.668 | 1196 | 3.692 | 0 |
| 336 | 889.873 | 2.674 | 1225 | 3.702 | 0 |
| 344 | 911.291 | 2.681 | 1255 | 3.711 | 0 |
| 352 | 932.76 | 2.687 | 1285 | 3.721 | 0 |
| 360 | 954.284 | 2.694 | 1314 | 3.732 | 0 |
| 368 | 975.863 | 2.701 | 1344 | 3.743 | 0 |
| 376 | 997.499 | 2.708 | 1374 | 3.754 | 0 |
| 384 | 1019.194 | 2.716 | 1404 | 3.765 | 0 |
| 392 | 1040.951 | 2.724 | 1435 | 3.777 | 0 |
| 400 | 1062.771 | 2.731 | 1465 | 3.789 | 0 |
| 408 | 1084.655 | 2.74 | 1495 | 3.801 | 0 |
| 416 | 1106.606 | 2.748 | 1526 | 3.814 | 0 |
| 424 | 1128.625 | 2.757 | 1556 | 3.827 | 0 |
| 432 | 1150.713 | 2.765 | 1587 | 3.84 | 0 |
| 440 | 1172.872 | 2.774 | 1618 | 3.853 | 0 |
| 448 | 1195.103 | 2.783 | 1649 | 3.867 | 0 |
| 456 | 1217.408 | 2.793 | 1680 | 3.881 | 0 |
| 464 | 1239.787 | 2.802 | 1711 | 3.895 | 0 |
| 472 | 1262.242 | 2.812 | 1742 | 3.909 | 0 |
| 480 | 1284.775 | 2.821 | 1773 | 3.924 | 0 |
| 488 | 1307.386 | 2.831 | 1805 | 3.939 | 0 |
| 496 | 1330.076 | 2.841 | 1836 | 3.954 | 0 |
| 504 | 1352.846 | 2.851 | 1868 | 3.969 | 0 |
| 512 | 1375.697 | 2.862 | 1900 | 3.984 | 0 |
| 520 | 1398.631 | 2.872 | 1932 | 4 | 0 |
| 528 | 1421.646 | 2.882 | 1964 | 4.015 | 0 |
| 536 | 1444.746 | 2.893 | 1996 | 4.031 | 0 |
| 544 | 1467.929 | 2.903 | 2028 | 4.047 | 0 |
| 552 | 1491.196 | 2.914 | 2061 | 4.062 | 0 |
| 560 | 1514.549 | 2.924 | 2093 | 4.079 | 0 |
| 568 | 1537.988 | 2.935 | 2126 | 4.095 | 0 |
| 576 | 1561.513 | 2.946 | 2159 | 4.111 | 0 |
| 584 | 1585.124 | 2.957 | 2192 | 4.127 | 0 |
| 592 | 1608.822 | 2.968 | 2225 | 4.143 | 0 |
| 600 | 1632.607 | 2.979 | 2258 | 4.16 | 0 |
| 608 | 1656.48 | 2.99 | 2291 | 4.176 | 0 |
| 616 | 1680.44 | 3 | 2325 | 4.193 | 0 |
| 624 | 1704.488 | 3.011 | 2358 | 4.209 | 0 |
| 632 | 1728.623 | 3.022 | 2392 | 4.226 | 0 |
| 640 | 1752.846 | 3.033 | 2426 | 4.242 | 0 |
| 648 | 1777.157 | 3.044 | 2460 | 4.259 | 0 |
| 656 | 1801.556 | 3.055 | 2494 | 4.275 | 0 |
| 664 | 1826.042 | 3.066 | 2528 | 4.292 | 0 |
| 672 | 1850.615 | 3.077 | 2563 | 4.309 | 0 |
| 680 | 1875.276 | 3.088 | 2597 | 4.325 | 0 |
| 688 | 1900.024 | 3.099 | 2632 | 4.342 | 0 |
| 696 | 1924.859 | 3.11 | 2667 | 4.358 | 0 |
| 704 | 1949.78 | 3.121 | 2702 | 4.374 | 0 |
| 712 | 1974.787 | 3.131 | 2737 | 4.391 | 0 |
| 720 | 1999.88 | 3.142 | 2772 | 4.407 | 0 |
| 728 | 2025.058 | 3.153 | 2807 | 4.423 | 0 |
| 736 | 2050.321 | 3.163 | 2843 | 4.44 | 0 |
| 744 | 2075.669 | 3.174 | 2878 | 4.456 | 0 |
| 752 | 2101.1 | 3.184 | 2914 | 4.472 | 0 |
| 760 | 2126.615 | 3.194 | 2950 | 4.487 | 0 |
| 768 | 2152.212 | 3.205 | 2986 | 4.503 | 0 |
| 776 | 2177.891 | 3.215 | 3022 | 4.519 | 0 |

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|---|---|---|---|---|---|
| 784 | 2203.652 | 3.225 | 3058 | 4.535 | 0 |
| 792 | 2229.493 | 3.235 | 3094 | 4.55 | 0 |
| 800 | 2255.415 | 3.245 | 3131 | 4.566 | 0 |
| 808 | 2281.416 | 3.255 | 3168 | 4.581 | 0 |
| 816 | 2307.495 | 3.265 | 3204 | 4.596 | 0 |
| 824 | 2333.652 | 3.274 | 3241 | 4.611 | 0 |
| 832 | 2359.886 | 3.284 | 3278 | 4.626 | 0 |
| 840 | 2386.197 | 3.293 | 3315 | 4.641 | 0 |
| 848 | 2412.582 | 3.303 | 3352 | 4.655 | 0 |
| 856 | 2439.042 | 3.312 | 3390 | 4.67 | 0 |
| 864 | 2465.575 | 3.321 | 3427 | 4.684 | 0 |
| 872 | 2492.181 | 3.33 | 3465 | 4.698 | 0 |
| 880 | 2518.859 | 3.339 | 3502 | 4.712 | 0 |
| 888 | 2545.607 | 3.348 | 3540 | 4.726 | 0 |
| 896 | 2572.425 | 3.357 | 3578 | 4.74 | 0 |
| 904 | 2599.312 | 3.365 | 3616 | 4.754 | 0.004 |
| 912 | 2626.267 | 3.374 | 3654 | 4.767 | 0.028 |
| 920 | 2653.287 | 3.382 | 3692 | 4.78 | 0.048 |
| 928 | 2680.372 | 3.39 | 3730 | 4.793 | 0.067 |
| 936 | 2707.52 | 3.397 | 3769 | 4.805 | 0.086 |
| 944 | 2734.729 | 3.405 | 3807 | 4.817 | 0.104 |
| 952 | 2761.997 | 3.412 | 3846 | 4.829 | 0.123 |
| 960 | 2789.323 | 3.419 | 3884 | 4.841 | 0.142 |
| 968 | 2816.704 | 3.426 | 3923 | 4.852 | 0.16 |
| 976 | 2844.14 | 3.433 | 3962 | 4.863 | 0.179 |
| 984 | 2871.628 | 3.439 | 4001 | 4.874 | 0.197 |
| 992 | 2899.166 | 3.445 | 4040 | 4.884 | 0.215 |
| 1000 | 2926.752 | 3.451 | 4079 | 4.894 | 0.233 |
| 1008 | 2954.384 | 3.457 | 4118 | 4.904 | 0.251 |
| 1016 | 2982.061 | 3.462 | 4158 | 4.913 | 0.268 |
| 1024 | 3009.78 | 3.467 | 4197 | 4.922 | 0.285 |
| 1032 | 3037.54 | 3.472 | 4236 | 4.93 | 0.303 |
| 1040 | 3065.338 | 3.477 | 4276 | 4.939 | 0.32 |
| 1048 | 3093.173 | 3.481 | 4315 | 4.946 | 0.337 |
| 1056 | 3121.042 | 3.486 | 4355 | 4.954 | 0.353 |
| 1064 | 3148.943 | 3.49 | 4395 | 4.961 | 0.37 |
| 1072 | 3176.875 | 3.493 | 4434 | 4.968 | 0.387 |
| 1080 | 3204.836 | 3.497 | 4474 | 4.975 | 0.403 |
| 1088 | 3232.822 | 3.5 | 4514 | 4.981 | 0.42 |
| 1096 | 3260.833 | 3.503 | 4554 | 4.986 | 0.436 |
| 1104 | 3288.866 | 3.505 | 4594 | 4.992 | 0.452 |
| 1112 | 3316.919 | 3.508 | 4634 | 4.997 | 0.469 |
| 1120 | 3344.99 | 3.51 | 4674 | 5.001 | 0.485 |
| 1128 | 3373.076 | 3.512 | 4714 | 5.006 | 0.501 |
| 1136 | 3401.177 | 3.513 | 4754 | 5.01 | 0.517 |
| 1144 | 3429.29 | 3.515 | 4794 | 5.013 | 0.533 |
| 1152 | 3457.412 | 3.516 | 4834 | 5.016 | 0.549 |
| 1160 | 3485.542 | 3.517 | 4874 | 5.019 | 0.565 |
| 1168 | 3513.677 | 3.517 | 4914 | 5.022 | 0.581 |
| 1176 | 3541.816 | 3.517 | 4955 | 5.024 | 0.597 |
| 1184 | 3569.955 | 3.517 | 4995 | 5.025 | 0.612 |
| 1192 | 3598.094 | 3.517 | 5035 | 5.027 | 0.628 |
| 1200 | 3626.23 | 3.517 | 5075 | 5.028 | 0.644 |
| 1208 | 3654.361 | 3.516 | 5115 | 5.028 | 0.659 |
| 1216 | 3682.485 | 3.515 | 5156 | 5.028 | 0.675 |
| 1224 | 3710.6 | 3.514 | 5196 | 5.028 | 0.69 |
| 1232 | 3738.704 | 3.512 | 5236 | 5.028 | 0.706 |
| 1240 | 3766.794 | 3.51 | 5276 | 5.027 | 0.721 |

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|---|---|---|---|---|---|
| 1248 | 3794.868 | 3.508 | 5316 | 5.025 | 0.737 |
| 1256 | 3822.926 | 3.506 | 5357 | 5.024 | 0.752 |
| 1264 | 3850.964 | 3.503 | 5397 | 5.022 | 0.767 |
| 1272 | 3878.981 | 3.501 | 5437 | 5.019 | 0.782 |
| 1280 | 3906.974 | 3.498 | 5477 | 5.017 | 0.798 |
| 1288 | 3934.941 | 3.494 | 5517 | 5.013 | 0.813 |
| 1296 | 3962.881 | 3.491 | 5557 | 5.01 | 0.828 |
| 1304 | 3990.791 | 3.487 | 5597 | 5.006 | 0.843 |
| 1312 | 4018.67 | 3.483 | 5637 | 5.002 | 0.858 |
| 1320 | 4046.516 | 3.478 | 5677 | 4.997 | 0.873 |
| 1328 | 4074.326 | 3.474 | 5717 | 4.992 | 0.888 |
| 1336 | 4102.099 | 3.469 | 5757 | 4.987 | 0.903 |
| 1344 | 4129.833 | 3.464 | 5797 | 4.981 | 0.917 |
| 1352 | 4157.525 | 3.459 | 5837 | 4.975 | 0.932 |
| 1360 | 4185.175 | 3.453 | 5877 | 4.969 | 0.947 |
| 1368 | 4212.779 | 3.448 | 5917 | 4.962 | 0.962 |
| 1376 | 4240.337 | 3.442 | 5956 | 4.956 | 0.976 |
| 1384 | 4267.847 | 3.436 | 5996 | 4.948 | 0.991 |
| 1392 | 4295.307 | 3.429 | 6035 | 4.94 | 1.005 |
| 1400 | 4322.714 | 3.423 | 6075 | 4.933 | 1.02 |
| 1408 | 4350.068 | 3.416 | 6114 | 4.924 | 1.034 |
| 1416 | 4377.366 | 3.409 | 6154 | 4.916 | 1.049 |
| 1424 | 4404.607 | 3.401 | 6193 | 4.907 | 1.063 |
| 1432 | 4431.789 | 3.394 | 6232 | 4.897 | 1.077 |
| 1440 | 4458.911 | 3.386 | 6271 | 4.888 | 1.091 |
| 1448 | 4485.971 | 3.378 | 6310 | 4.878 | 1.105 |
| 1456 | 4512.967 | 3.371 | 6349 | 4.868 | 1.119 |
| 1464 | 4539.898 | 3.362 | 6388 | 4.858 | 1.134 |
| 1472 | 4566.763 | 3.354 | 6427 | 4.847 | 1.148 |
| 1480 | 4593.559 | 3.345 | 6466 | 4.836 | 1.161 |
| 1488 | 4620.285 | 3.336 | 6504 | 4.825 | 1.175 |
| 1496 | 4646.941 | 3.327 | 6543 | 4.813 | 1.189 |
| 1504 | 4673.524 | 3.318 | 6581 | 4.802 | 1.203 |
| 1512 | 4700.033 | 3.309 | 6620 | 4.79 | 1.217 |
| 1520 | 4726.468 | 3.299 | 6658 | 4.777 | 1.23 |
| 1528 | 4752.825 | 3.29 | 6696 | 4.765 | 1.244 |
| 1536 | 4779.106 | 3.28 | 6734 | 4.752 | 1.257 |
| 1544 | 4805.307 | 3.27 | 6772 | 4.739 | 1.271 |
| 1552 | 4831.429 | 3.26 | 6810 | 4.726 | 1.284 |
| 1560 | 4857.469 | 3.25 | 6848 | 4.712 | 1.298 |
| 1568 | 4883.428 | 3.24 | 6886 | 4.699 | 1.311 |
| 1576 | 4909.303 | 3.229 | 6923 | 4.685 | 1.324 |
| 1584 | 4935.094 | 3.219 | 6961 | 4.671 | 1.337 |
| 1592 | 4960.799 | 3.208 | 6998 | 4.657 | 1.35 |
| 1600 | 4986.419 | 3.197 | 7035 | 4.643 | 1.363 |
| 1608 | 5011.951 | 3.186 | 7072 | 4.628 | 1.376 |
| 1616 | 5037.396 | 3.175 | 7109 | 4.613 | 1.389 |
| 1624 | 5062.753 | 3.164 | 7146 | 4.599 | 1.402 |
| 1632 | 5088.02 | 3.153 | 7183 | 4.584 | 1.415 |
| 1640 | 5113.197 | 3.141 | 7219 | 4.569 | 1.427 |
| 1648 | 5138.283 | 3.13 | 7256 | 4.553 | 1.44 |
| 1656 | 5163.279 | 3.119 | 7292 | 4.538 | 1.452 |
| 1664 | 5188.182 | 3.107 | 7328 | 4.523 | 1.465 |
| 1672 | 5212.994 | 3.096 | 7364 | 4.507 | 1.477 |
| 1680 | 5237.713 | 3.084 | 7400 | 4.491 | 1.489 |
| 1688 | 5262.339 | 3.072 | 7436 | 4.476 | 1.502 |
| 1696 | 5286.871 | 3.061 | 7472 | 4.46 | 1.514 |
| 1704 | 5311.31 | 3.049 | 7508 | 4.444 | 1.526 |

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|---|---|---|---|---|---|
| 1712 | 5335.655 | 3.037 | 7543 | 4.428 | 1.538 |
| 1720 | 5359.906 | 3.026 | 7579 | 4.412 | 1.55 |
| 1728 | 5384.063 | 3.014 | 7614 | 4.396 | 1.562 |
| 1736 | 5408.126 | 3.002 | 7649 | 4.38 | 1.574 |
| 1744 | 5432.095 | 2.99 | 7684 | 4.364 | 1.586 |
| 1752 | 5455.969 | 2.978 | 7719 | 4.348 | 1.597 |
| 1760 | 5479.75 | 2.967 | 7753 | 4.332 | 1.609 |
| 1768 | 5503.436 | 2.955 | 7788 | 4.316 | 1.621 |
| 1776 | 5527.029 | 2.943 | 7822 | 4.301 | 1.632 |
| 1784 | 5550.528 | 2.932 | 7857 | 4.285 | 1.644 |
| 1792 | 5573.935 | 2.92 | 7891 | 4.269 | 1.656 |
| 1800 | 5597.248 | 2.908 | 7925 | 4.253 | 1.667 |
| 1808 | 5620.461 | 2.895 | 7959 | 4.234 | 1.678 |
| 1816 | 5643.564 | 2.881 | 7993 | 4.215 | 1.69 |
| 1824 | 5666.556 | 2.867 | 8027 | 4.196 | 1.701 |
| 1832 | 5689.439 | 2.854 | 8060 | 4.177 | 1.713 |
| 1840 | 5712.214 | 2.84 | 8093 | 4.158 | 1.724 |
| 1848 | 5734.88 | 2.826 | 8127 | 4.14 | 1.735 |
| 1856 | 5757.439 | 2.813 | 8160 | 4.121 | 1.746 |
| 1864 | 5779.891 | 2.8 | 8192 | 4.103 | 1.758 |
| 1872 | 5802.237 | 2.787 | 8225 | 4.084 | 1.769 |
| 1880 | 5824.479 | 2.774 | 8258 | 4.066 | 1.78 |
| 1888 | 5846.616 | 2.761 | 8290 | 4.048 | 1.791 |
| 1896 | 5868.651 | 2.748 | 8323 | 4.031 | 1.802 |
| 1904 | 5890.583 | 2.735 | 8355 | 4.013 | 1.813 |
| 1912 | 5912.415 | 2.723 | 8387 | 3.996 | 1.824 |
| 1920 | 5934.148 | 2.71 | 8419 | 3.979 | 1.835 |
| 1928 | 5955.782 | 2.698 | 8450 | 3.962 | 1.846 |
| 1936 | 5977.32 | 2.686 | 8482 | 3.945 | 1.857 |
| 1944 | 5998.762 | 2.674 | 8514 | 3.928 | 1.868 |
| 1952 | 6020.11 | 2.663 | 8545 | 3.912 | 1.879 |
| 1960 | 6041.365 | 2.651 | 8576 | 3.896 | 1.89 |
| 1968 | 6062.53 | 2.64 | 8607 | 3.881 | 1.901 |
| 1976 | 6083.605 | 2.629 | 8638 | 3.865 | 1.912 |
| 1984 | 6104.593 | 2.618 | 8669 | 3.85 | 1.923 |
| 1992 | 6125.495 | 2.608 | 8700 | 3.836 | 1.934 |
| 2000 | 6146.313 | 2.597 | 8731 | 3.821 | 1.945 |
| 2008 | 6167.049 | 2.587 | 8761 | 3.807 | 1.956 |
| 2016 | 6187.704 | 2.577 | 8791 | 3.794 | 1.967 |
| 2024 | 6208.282 | 2.567 | 8822 | 3.78 | 1.978 |
| 2032 | 6228.783 | 2.558 | 8852 | 3.767 | 1.988 |
| 2040 | 6249.21 | 2.549 | 8882 | 3.755 | 1.999 |
| 2048 | 6269.566 | 2.54 | 8912 | 3.743 | 2.01 |
| 2056 | 6289.852 | 2.532 | 8942 | 3.731 | 2.021 |
| 2064 | 6310.07 | 2.523 | 8972 | 3.719 | 2.032 |
| 2072 | 6330.223 | 2.515 | 9001 | 3.709 | 2.043 |
| 2080 | 6350.315 | 2.508 | 9031 | 3.698 | 2.054 |
| 2088 | 6370.345 | 2.5 | 9061 | 3.688 | 2.065 |
| 2096 | 6390.319 | 2.493 | 9090 | 3.678 | 2.076 |
| 2104 | 6410.236 | 2.486 | 9119 | 3.669 | 2.087 |
| 2112 | 6430.102 | 2.48 | 9149 | 3.661 | 2.098 |
| 2120 | 6449.918 | 2.474 | 9178 | 3.653 | 2.109 |
| 2128 | 6469.687 | 2.468 | 9207 | 3.645 | 2.12 |
| 2136 | 6489.411 | 2.463 | 9236 | 3.638 | 2.131 |
| 2144 | 6509.094 | 2.458 | 9265 | 3.631 | 2.142 |
| 2152 | 6528.738 | 2.453 | 9294 | 3.625 | 2.153 |
| 2160 | 6548.347 | 2.449 | 9323 | 3.62 | 2.164 |
| 2168 | 6567.923 | 2.445 | 9352 | 3.615 | 2.175 |

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|---|---|---|---|---|---|
| 2176 | 6587.469 | 2.441 | 9381 | 3.61 | 2.186 |
| 2184 | 6606.988 | 2.438 | 9410 | 3.606 | 2.197 |
| 2192 | 6626.484 | 2.436 | 9439 | 3.603 | 2.209 |
| 2200 | 6645.96 | 2.433 | 9468 | 3.601 | 2.22 |
| 2208 | 6665.419 | 2.431 | 9497 | 3.598 | 2.231 |
| 2216 | 6684.863 | 2.43 | 9525 | 3.597 | 2.242 |
| 2224 | 6704.296 | 2.429 | 9554 | 3.596 | 2.254 |
| 2232 | 6723.723 | 2.428 | 9583 | 3.596 | 2.265 |
| 2240 | 6743.145 | 2.428 | 9612 | 3.596 | 2.276 |
| 2248 | 6762.567 | 2.428 | 9640 | 3.597 | 2.288 |
| 2256 | 6781.991 | 2.428 | 9669 | 3.599 | 2.299 |
| 2264 | 6801.421 | 2.429 | 9698 | 3.601 | 2.311 |
| 2272 | 6820.861 | 2.431 | 9727 | 3.604 | 2.322 |
| 2280 | 6840.315 | 2.433 | 9756 | 3.607 | 2.334 |
| 2288 | 6859.785 | 2.435 | 9785 | 3.612 | 2.345 |
| 2296 | 6879.275 | 2.438 | 9813 | 3.616 | 2.357 |
| 2304 | 6898.789 | 2.441 | 9842 | 3.622 | 2.369 |
| 2312 | 6918.331 | 2.445 | 9871 | 3.628 | 2.381 |
| 2320 | 6937.903 | 2.449 | 9900 | 3.635 | 2.394 |
| 2328 | 6957.51 | 2.453 | 9930 | 3.642 | 2.408 |
| 2336 | 6977.153 | 2.458 | 9959 | 3.65 | 2.423 |
| 2344 | 6996.836 | 2.463 | 9988 | 3.659 | 2.439 |
| 2352 | 7016.562 | 2.468 | 10017 | 3.668 | 2.455 |
| 2360 | 7036.332 | 2.474 | 10047 | 3.677 | 2.472 |
| 2368 | 7056.149 | 2.48 | 10076 | 3.687 | 2.489 |
| 2376 | 7076.014 | 2.486 | 10106 | 3.697 | 2.508 |
| 2384 | 7095.93 | 2.493 | 10135 | 3.707 | 2.527 |
| 2392 | 7115.898 | 2.499 | 10165 | 3.718 | 2.546 |
| 2400 | 7135.919 | 2.506 | 10195 | 3.728 | 2.566 |
| 2408 | 7155.993 | 2.513 | 10225 | 3.739 | 2.587 |
| 2416 | 7176.123 | 2.52 | 10255 | 3.75 | 2.608 |
| 2424 | 7196.308 | 2.527 | 10285 | 3.762 | 2.63 |
| 2432 | 7216.549 | 2.534 | 10315 | 3.773 | 2.652 |
| 2440 | 7236.845 | 2.54 | 10345 | 3.784 | 2.675 |
| 2448 | 7257.197 | 2.547 | 10375 | 3.795 | 2.698 |
| 2456 | 7277.604 | 2.554 | 10406 | 3.806 | 2.722 |
| 2464 | 7298.066 | 2.561 | 10436 | 3.817 | 2.746 |
| 2472 | 7318.581 | 2.568 | 10467 | 3.828 | 2.771 |
| 2480 | 7339.148 | 2.574 | 10497 | 3.838 | 2.796 |
| 2488 | 7359.765 | 2.58 | 10528 | 3.849 | 2.821 |
| 2496 | 7380.432 | 2.586 | 10559 | 3.858 | 2.847 |
| 2504 | 7401.145 | 2.592 | 10590 | 3.868 | 2.873 |
| 2512 | 7421.902 | 2.597 | 10621 | 3.877 | 2.9 |
| 2520 | 7442.701 | 2.602 | 10652 | 3.885 | 2.926 |
| 2528 | 7463.539 | 2.607 | 10683 | 3.893 | 2.954 |
| 2536 | 7484.412 | 2.611 | 10714 | 3.9 | 2.981 |
| 2544 | 7505.318 | 2.615 | 10745 | 3.907 | 3.009 |
| 2552 | 7526.251 | 2.618 | 10777 | 3.912 | 3.037 |
| 2560 | 7547.209 | 2.621 | 10808 | 3.917 | 3.065 |
| 2568 | 7568.186 | 2.623 | 10839 | 3.922 | 3.093 |
| 2576 | 7589.179 | 2.625 | 10871 | 3.925 | 3.122 |
| 2584 | 7610.183 | 2.626 | 10902 | 3.927 | 3.151 |
| 2592 | 7631.19 | 2.626 | 10934 | 3.929 | 3.18 |
| 2600 | 7652.198 | 2.626 | 10965 | 3.929 | 3.209 |
| 2608 | 7673.201 | 2.625 | 10997 | 3.928 | 3.238 |
| 2616 | 7694.192 | 2.623 | 11028 | 3.927 | 3.268 |
| 2624 | 7715.165 | 2.62 | 11059 | 3.924 | 3.297 |
| 2632 | 7736.115 | 2.617 | 11091 | 3.919 | 3.327 |

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|---|---|---|---|---|---|
| 2640 | 7757.034 | 2.613 | 11122 | 3.914 | 3.356 |
| 2648 | 7777.915 | 2.608 | 11153 | 3.908 | 3.386 |
| 2656 | 7798.754 | 2.602 | 11185 | 3.9 | 3.416 |
| 2664 | 7819.542 | 2.595 | 11216 | 3.89 | 3.446 |
| 2672 | 7840.272 | 2.587 | 11247 | 3.88 | 3.476 |
| 2680 | 7860.937 | 2.579 | 11278 | 3.868 | 3.506 |
| 2688 | 7881.529 | 2.569 | 11309 | 3.854 | 3.535 |
| 2696 | 7902.042 | 2.559 | 11339 | 3.84 | 3.565 |
| 2704 | 7922.469 | 2.547 | 11370 | 3.823 | 3.595 |
| 2712 | 7942.801 | 2.535 | 11401 | 3.806 | 3.625 |
| 2720 | 7963.031 | 2.522 | 11431 | 3.787 | 3.655 |
| 2728 | 7983.151 | 2.508 | 11461 | 3.767 | 3.684 |
| 2736 | 8003.156 | 2.493 | 11491 | 3.745 | 3.714 |
| 2744 | 8023.037 | 2.477 | 11521 | 3.722 | 3.743 |
| 2752 | 8042.788 | 2.46 | 11551 | 3.697 | 3.772 |
| 2760 | 8062.4 | 2.443 | 11580 | 3.672 | 3.801 |
| 2768 | 8081.867 | 2.424 | 11610 | 3.645 | 3.83 |
| 2776 | 8101.184 | 2.405 | 11639 | 3.616 | 3.859 |
| 2784 | 8120.343 | 2.385 | 11667 | 3.587 | 3.888 |
| 2792 | 8139.336 | 2.364 | 11696 | 3.556 | 3.916 |
| 2800 | 8158.162 | 2.342 | 11724 | 3.524 | 3.944 |
| 2808 | 8176.811 | 2.32 | 11752 | 3.492 | 3.972 |
| 2816 | 8195.279 | 2.297 | 11780 | 3.458 | 4 |
| 2824 | 8213.563 | 2.273 | 11808 | 3.423 | 4.027 |
| 2832 | 8231.654 | 2.249 | 11835 | 3.388 | 4.055 |
| 2840 | 8249.551 | 2.225 | 11862 | 3.351 | 4.082 |
| 2848 | 8267.249 | 2.2 | 11889 | 3.314 | 4.108 |
| 2856 | 8284.746 | 2.174 | 11915 | 3.276 | 4.135 |
| 2864 | 8302.038 | 2.149 | 11941 | 3.238 | 4.161 |
| 2872 | 8319.123 | 2.122 | 11967 | 3.2 | 4.186 |
| 2880 | 8335.998 | 2.096 | 11992 | 3.161 | 4.212 |
| 2888 | 8352.663 | 2.07 | 12017 | 3.121 | 4.237 |
| 2896 | 8369.117 | 2.043 | 12042 | 3.082 | 4.261 |
| 2904 | 8385.357 | 2.017 | 12067 | 3.043 | 4.285 |
| 2912 | 8401.388 | 1.991 | 12091 | 3.003 | 4.309 |
| 2920 | 8417.208 | 1.964 | 12115 | 2.964 | 4.333 |
| 2928 | 8432.819 | 1.938 | 12138 | 2.925 | 4.356 |
| 2936 | 8448.222 | 1.913 | 12161 | 2.887 | 4.378 |
| 2944 | 8463.421 | 1.887 | 12184 | 2.849 | 4.4 |
| 2952 | 8478.419 | 1.862 | 12207 | 2.812 | 4.422 |
| 2960 | 8493.222 | 1.838 | 12229 | 2.776 | 4.443 |
| 2968 | 8507.831 | 1.814 | 12252 | 2.741 | 4.464 |
| 2976 | 8522.254 | 1.791 | 12273 | 2.707 | 4.484 |
| 2984 | 8536.497 | 1.769 | 12295 | 2.673 | 4.504 |
| 2992 | 8550.564 | 1.748 | 12316 | 2.642 | 4.524 |
| 3000 | 8564.468 | 1.728 | 12337 | 2.611 | 4.543 |
| 3008 | 8578.209 | 1.708 | 12358 | 2.582 | 4.562 |
| 3016 | 8591.799 | 1.69 | 12378 | 2.555 | 4.58 |
| 3024 | 8605.245 | 1.672 | 12399 | 2.528 | 4.598 |
| 3032 | 8618.556 | 1.656 | 12419 | 2.504 | 4.616 |
| 3040 | 8631.74 | 1.641 | 12439 | 2.482 | 4.634 |
| 3048 | 8644.81 | 1.627 | 12459 | 2.461 | 4.651 |
| 3056 | 8657.771 | 1.614 | 12478 | 2.442 | 4.668 |
| 3064 | 8670.634 | 1.602 | 12498 | 2.425 | 4.684 |
| 3072 | 8683.411 | 1.592 | 12517 | 2.41 | 4.7 |
| 3080 | 8696.113 | 1.584 | 12536 | 2.397 | 4.716 |
| 3088 | 8708.752 | 1.576 | 12555 | 2.386 | 4.731 |
| 3096 | 8721.335 | 1.57 | 12574 | 2.377 | 4.747 |

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|---|---|---|---|---|---|
| 3104 | 8733.877 | 1.566 | 12593 | 2.371 | 4.761 |
| 3112 | 8746.389 | 1.563 | 12612 | 2.367 | 4.776 |
| 3120 | 8758.882 | 1.561 | 12631 | 2.365 | 4.79 |
| 3128 | 8771.37 | 1.561 | 12650 | 2.365 | 4.804 |
| 3136 | 8783.866 | 1.563 | 12669 | 2.368 | 4.817 |
| 3144 | 8796.378 | 1.566 | 12688 | 2.373 | 4.83 |
| 3152 | 8808.923 | 1.571 | 12707 | 2.38 | 4.843 |
| 3160 | 8821.513 | 1.577 | 12726 | 2.39 | 4.856 |
| 3168 | 8834.161 | 1.585 | 12745 | 2.403 | 4.868 |
| 3176 | 8846.877 | 1.594 | 12765 | 2.418 | 4.88 |
| 3184 | 8859.677 | 1.606 | 12784 | 2.435 | 4.891 |
| 3192 | 8872.571 | 1.618 | 12804 | 2.454 | 4.902 |
| 3200 | 8885.575 | 1.633 | 12823 | 2.477 | 4.913 |
| 3208 | 8898.699 | 1.648 | 12843 | 2.501 | 4.924 |
| 3216 | 8911.956 | 1.666 | 12863 | 2.528 | 4.934 |
| 3224 | 8925.356 | 1.685 | 12884 | 2.557 | 4.944 |
| 3232 | 8938.915 | 1.705 | 12904 | 2.588 | 4.953 |
| 3240 | 8952.644 | 1.727 | 12925 | 2.621 | 4.963 |
| 3248 | 8966.551 | 1.75 | 12946 | 2.657 | 4.972 |
| 3256 | 8980.648 | 1.775 | 12968 | 2.695 | 4.98 |
| 3264 | 8994.947 | 1.801 | 12989 | 2.734 | 4.989 |
| 3272 | 9009.458 | 1.827 | 13011 | 2.776 | 4.997 |
| 3280 | 9024.19 | 1.856 | 13034 | 2.819 | 5.004 |
| 3288 | 9039.155 | 1.885 | 13056 | 2.864 | 5.012 |
| 3296 | 9054.356 | 1.916 | 13080 | 2.911 | 5.019 |
| 3304 | 9069.806 | 1.947 | 13103 | 2.959 | 5.025 |
| 3312 | 9085.512 | 1.98 | 13127 | 3.009 | 5.032 |
| 3320 | 9101.479 | 2.013 | 13151 | 3.06 | 5.038 |
| 3328 | 9117.718 | 2.047 | 13176 | 3.112 | 5.044 |
| 3336 | 9134.229 | 2.082 | 13201 | 3.166 | 5.049 |
| 3344 | 9151.023 | 2.117 | 13227 | 3.22 | 5.054 |
| 3352 | 9168.099 | 2.152 | 13252 | 3.274 | 5.059 |
| 3360 | 9185.448 | 2.186 | 13279 | 3.327 | 5.064 |
| 3368 | 9203.074 | 2.22 | 13306 | 3.379 | 5.068 |
| 3376 | 9220.969 | 2.254 | 13333 | 3.431 | 5.072 |
| 3384 | 9239.13 | 2.287 | 13361 | 3.482 | 5.076 |
| 3392 | 9257.555 | 2.319 | 13389 | 3.532 | 5.079 |
| 3400 | 9276.239 | 2.352 | 13417 | 3.582 | 5.082 |
| 3408 | 9295.179 | 2.383 | 13446 | 3.631 | 5.085 |
| 3416 | 9314.371 | 2.415 | 13475 | 3.68 | 5.087 |
| 3424 | 9333.813 | 2.446 | 13505 | 3.728 | 5.089 |
| 3432 | 9353.503 | 2.476 | 13535 | 3.775 | 5.091 |
| 3440 | 9373.434 | 2.507 | 13565 | 3.822 | 5.093 |
| 3448 | 9393.606 | 2.536 | 13596 | 3.869 | 5.094 |
| 3456 | 9414.015 | 2.566 | 13627 | 3.914 | 5.095 |
| 3464 | 9434.658 | 2.595 | 13659 | 3.96 | 5.095 |
| 3472 | 9455.533 | 2.624 | 13691 | 4.004 | 5.096 |
| 3480 | 9476.636 | 2.652 | 13723 | 4.049 | 5.096 |
| 3488 | 9497.966 | 2.68 | 13755 | 4.093 | 5.095 |
| 3496 | 9519.52 | 2.708 | 13788 | 4.136 | 5.095 |
| 3504 | 9541.295 | 2.736 | 13821 | 4.179 | 5.094 |
| 3512 | 9563.29 | 2.763 | 13855 | 4.222 | 5.093 |
| 3520 | 9585.502 | 2.79 | 13889 | 4.264 | 5.091 |
| 3528 | 9607.93 | 2.817 | 13923 | 4.306 | 5.089 |
| 3536 | 9630.569 | 2.843 | 13958 | 4.348 | 5.087 |
| 3544 | 9653.422 | 2.87 | 13993 | 4.389 | 5.085 |
| 3552 | 9676.482 | 2.896 | 14028 | 4.43 | 5.082 |
| 3560 | 9699.751 | 2.921 | 14064 | 4.471 | 5.079 |

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|---|---|---|---|---|---|
| 3568 | 9723.226 | 2.947 | 14100 | 4.511 | 5.076 |
| 3576 | 9746.906 | 2.973 | 14136 | 4.551 | 5.072 |
| 3584 | 9770.789 | 2.998 | 14172 | 4.591 | 5.068 |
| 3592 | 9794.874 | 3.023 | 14209 | 4.631 | 5.064 |
| 3600 | 9819.158 | 3.048 | 14247 | 4.671 | 5.06 |
| 3608 | 9843.643 | 3.073 | 14284 | 4.71 | 5.055 |
| 3616 | 9868.33 | 3.098 | 14322 | 4.749 | 5.05 |
| 3624 | 9893.209 | 3.122 | 14360 | 4.788 | 0.5 |
| 3632 | 9918.271 | 3.144 | 14399 | 4.822 | 0.5 |
| 3640 | 9943.764 | 3.349 | 14438 | 5.138 | 0.5 |
| 3648 | 9972.842 | 3.915 | 14482 | 6.009 | 0.5 |
| 3656 | 10006.35 | 4.479 | 14534 | 6.877 | 0.5 |
| 3664 | 10044.45 | 5.04 | 14592 | 7.741 | 0.5 |
| 3672 | 10087.06 | 5.598 | 14658 | 8.603 | 0.5 |
| 3680 | 10134 | 6.139 | 14736 | 7.97 | 0.5 |
| 3688 | 10184.6 | 6.523 | 14802 | 8.593 | 0.5 |
| 3696 | 10238.25 | 6.878 | 14873 | 9.2 | 0.5 |
| 3704 | 10294.66 | 7.222 | 14949 | 9.813 | 0.5 |
| 3712 | 10353.75 | 7.546 | 15030 | 10.421 | 0.5 |
| 3720 | 10415.34 | 7.85 | 15116 | 11.024 | 0.5 |
| 3728 | 10479.28 | 8.135 | 15206 | 11.62 | 0.5 |
| 3736 | 10545.44 | 8.4 | 15302 | 12.209 | 0.5 |
| 3744 | 10613.65 | 8.645 | 15402 | 12.788 | 0.5 |
| 3752 | 10683.73 | 8.871 | 15506 | 13.356 | 0.5 |
| 3760 | 10755.53 | 9.078 | 15615 | 13.913 | 0.5 |
| 3768 | 10828.9 | 9.265 | 15729 | 14.456 | 0.5 |
| 3776 | 10903.72 | 9.434 | 15847 | 14.986 | 0.5 |
| 3784 | 10979.81 | 9.585 | 15969 | 15.501 | 0.5 |
| 3792 | 11057.04 | 9.718 | 16095 | 16 | 0.5 |
| 3800 | 11135.25 | 9.835 | 16224 | 16.483 | 0.5 |
| 3808 | 11214.34 | 9.936 | 16358 | 16.948 | 0.5 |
| 3816 | 11294.18 | 10.021 | 16496 | 17.395 | 0.5 |
| 3824 | 11374.64 | 10.091 | 16636 | 17.823 | 0.5 |
| 3832 | 11455.61 | 10.148 | 16781 | 18.234 | 0.5 |
| 3840 | 11536.97 | 10.191 | 16928 | 18.624 | 0.5 |
| 3848 | 11618.62 | 10.222 | 17079 | 18.995 | 0.5 |
| 3856 | 11700.49 | 10.241 | 17232 | 19.347 | 0.5 |
| 3864 | 11782.46 | 10.249 | 17388 | 19.679 | 0.5 |
| 3872 | 11864.44 | 10.247 | 17547 | 19.992 | 0.5 |
| 3880 | 11946.38 | 10.235 | 17708 | 20.285 | 0.5 |
| 3888 | 12028.18 | 10.215 | 17871 | 20.561 | 0.5 |
| 3896 | 12109.79 | 10.185 | 18037 | 20.814 | 0.5 |
| 3904 | 12191.14 | 10.149 | 18204 | 21.052 | 0.5 |
| 3912 | 12272.15 | 10.105 | 18374 | 21.269 | 0.5 |
| 3920 | 12352.79 | 10.054 | 18545 | 21.468 | 0.5 |
| 3928 | 12432.99 | 9.997 | 18717 | 21.649 | 0.5 |
| 3936 | 12512.73 | 9.935 | 18891 | 21.813 | 0.5 |
| 3944 | 12591.94 | 9.867 | 19066 | 21.959 | 0.5 |
| 3952 | 12670.59 | 9.795 | 19242 | 22.089 | 0.5 |
| 3960 | 12748.65 | 9.718 | 19419 | 22.202 | 0.5 |
| 3968 | 12826.07 | 9.637 | 19597 | 22.299 | 0.5 |
| 3976 | 12902.83 | 9.553 | 19776 | 22.381 | 0.5 |
| 3984 | 12978.91 | 9.465 | 19955 | 22.447 | 0.5 |
| 3992 | 13054.27 | 9.374 | 20135 | 22.497 | 0.5 |
| 4000 | 13128.89 | 9.28 | 20315 | 22.533 | 0.5 |
| 4008 | 13202.75 | 9.184 | 20496 | 22.555 | 0.5 |
| 4016 | 13275.83 | 9.085 | 20676 | 22.563 | 0.5 |
| 4024 | 13348.11 | 8.984 | 20857 | 22.557 | 0.5 |

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|---|---|---|---|---|---|
| 4032 | 13419.57 | 8.881 | 21037 | 22.537 | 0.5 |
| 4040 | 13490.19 | 8.776 | 21217 | 22.504 | 0.5 |
| 4048 | 13559.97 | 8.669 | 21397 | 22.458 | 0.5 |
| 4056 | 13628.89 | 8.56 | 21577 | 22.399 | 0.5 |
| 4064 | 13696.93 | 8.45 | 21756 | 22.327 | 0.5 |
| 4072 | 13764.08 | 8.338 | 21934 | 22.243 | 0.5 |
| 4080 | 13830.33 | 8.224 | 22111 | 22.145 | 0.5 |
| 4088 | 13895.66 | 8.109 | 22288 | 22.036 | 0.5 |
| 4096 | 13960.07 | 7.993 | 22464 | 21.913 | 0.5 |
| 4104 | 14023.54 | 7.875 | 22639 | 21.778 | 0.5 |
| 4112 | 14086.06 | 7.755 | 22812 | 21.63 | 0.5 |
| 4120 | 14147.62 | 7.634 | 22985 | 21.47 | 0.5 |
| 4128 | 14208.2 | 7.511 | 23156 | 21.297 | 0.5 |
| 4136 | 14267.8 | 7.387 | 23325 | 21.11 | 0.5 |
| 4144 | 14326.39 | 7.261 | 23494 | 20.91 | 0.5 |
| 4152 | 14383.96 | 7.133 | 23660 | 20.696 | 0.5 |
| 4160 | 14440.5 | 7.002 | 23825 | 20.467 | 0.5 |
| 4168 | 14495.99 | 6.87 | 23987 | 20.224 | 0.5 |
| 4176 | 14550.41 | 6.735 | 24148 | 19.965 | 0.5 |
| 4184 | 14603.75 | 6.598 | 24307 | 19.691 | 0.5 |
| 4192 | 14655.97 | 6.457 | 24463 | 19.399 | 0.5 |
| 4200 | 14707.05 | 6.314 | 24617 | 19.09 | 0.5 |
| 4208 | 14756.98 | 6.167 | 24769 | 18.761 | 0.5 |
| 4216 | 14805.71 | 6.016 | 24917 | 18.413 | 0.5 |
| 4224 | 14853.22 | 5.86 | 25063 | 18.042 | 0.5 |
| 4232 | 14899.47 | 5.7 | 25206 | 17.648 | 0.5 |
| 4240 | 14944.41 | 5.534 | 25345 | 17.227 | 0.5 |
| 4248 | 14987.99 | 5.361 | 25481 | 16.778 | 0.5 |
| 4256 | 15030.18 | 5.18 | 25912 | 23.014 | 0.66875 |
| 4264 | 15070.87 | 4.992 | 26101 | 24.046 | 0.96875 |
| 4272 | 15110.02 | 4.805 | 26296 | 24.87 | 1.25 |
| 4280 | 15147.86 | 4.656 | 26499 | 25.719 | 1.25 |
| 4288 | 15184.61 | 4.535 | 26708 | 26.581 | 1.25 |
| 4296 | 15212 | 4.437 | 26878 | 27.472 | 1.25 |
| 4304 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4312 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4320 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4328 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4336 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4344 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4352 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4360 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4368 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4376 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4384 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4392 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4400 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4408 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4416 | 15212 | 0 | 26878 | 0 | 1.25 |
| 4424 | 15212 | 0 | 26878 | 0 | 1.23843 |
| 4432 | 15212 | 0 | 26878 | 0 | 1.20138 |
| 4440 | 15212 | 0 | 26878 | 0 | 1.16434 |
| 4448 | 15212 | 0 | 26878 | 0 | 1.12731 |
| 4456 | 15212 | 0 | 26878 | 0 | 1.09027 |
| 4464 | 15212 | 0 | 26878 | 0 | 1.05323 |
| 4472 | 15212 | 0 | 26878 | 0 | 1.01619 |
| 4480 | 15212 | 0 | 26878 | 0 | 0.979145 |
| 4488 | 15212 | 0 | 26878 | 0 | 0.942105 |

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|---|---|---|---|---|---|
| 4496 | 15212 | 0 | 26878 | 0 | 0.905065 |
| 4504 | 15212 | 0 | 26878 | 0 | 0.868025 |
| 4512 | 15212 | 0 | 26878 | 0 | 0.830985 |
| 4520 | 15212 | 0 | 26878 | 0 | 0.793945 |
| 4528 | 15212 | 0 | 26878 | 0 | 0.756905 |
| 4536 | 15212 | 0 | 26878 | 0 | 0.719865 |
| 4544 | 15212 | 0 | 26878 | 0 | 0.682825 |
| 4552 | 15212 | 0 | 26878 | 0 | 0.645785 |
| 4560 | 15212 | 0 | 26878 | 0 | 0.608745 |
| 4568 | 15212 | 0 | 26878 | 0 | 0.571705 |
| 4576 | 15212 | 0 | 26878 | 0 | 0.534665 |
| 4584 | 15212 | 0 | 26878 | 0 | 0.497625 |
| 4592 | 15212 | 0 | 26878 | 0 | 0.460585 |
| 4600 | 15212 | 0 | 26878 | 0 | 0.423545 |
| 4608 | 15212 | 0 | 26878 | 0 | 0.386505 |
| 4616 | 15212 | 0 | 26878 | 0 | 0.349465 |
| 4624 | 15212 | 0 | 26878 | 0 | 0.312425 |
| 4632 | 15212 | 0 | 26878 | 0 | 0.275385 |
| 4640 | 15212 | 0 | 26878 | 0 | 0.238345 |
| 4648 | 15212 | 0 | 26878 | 0 | 0.201305 |
| 4656 | 15212 | 0 | 26878 | 0 | 0.164265 |
| 4664 | 15212 | 0 | 26878 | 0 | 0.127225 |
| 4672 | 15212 | 0 | 26878 | 0 | 0.090185 |
| 4680 | 15212 | 0 | 26878 | 0 | 0.053145 |
| 4688 | 15212 | 0 | 26878 | 0 | 0.016105 |
| 4696 | 15212 | 0 | 26878 | 0 | 0 |
| 4704 | 15212 | 0 | 26878 | 0 | 0 |
| 4712 | 15212 | 0 | 26878 | 0 | 0 |
| 4720 | 15212 | 0 | 26878 | 0 | 0 |
| 4728 | 15212 | 0 | 26878 | 0 | 0 |
| 4736 | 15212 | 0 | 26878 | 0 | 0 |
| 4744 | 15212 | 0 | 26878 | 0 | 0 |
| 4752 | 15212 | 0 | 26878 | 0 | 0 |
| 4760 | 15212 | 0 | 26878 | 0 | 0 |
| 4768 | 15212 | 0 | 26878 | 0 | 0 |
| 4776 | 15212 | 0 | 26878 | 0 | 0 |
| 4784 | 15212 | 0 | 26878 | 0 | 0 |
| 4792 | 15212 | 0 | 26878 | 0 | 0 |
| 4800 | 15212 | 0 | 26878 | 0 | 0 |
| 4808 | 15212 | 0 | 26878 | 0 | 0 |
| 4816 | 15212 | 0 | 26878 | 0 | 0 |
| 4824 | 15212 | 0 | 26878 | 0 | 0 |
| 4832 | 15212 | 0 | 26878 | 0 | 0 |
| 4840 | 15212 | 0 | 26878 | 0 | 0 |
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| 4872 | 15212 | 0 | 26878 | 0 | 0 |
| 4880 | 15212 | 0 | 26878 | 0 | 0 |
| 4888 | 15212 | 0 | 26878 | 0 | 0 |
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| 4904 | 15212 | 0 | 26878 | 0 | 0 |
| 4912 | 15212 | 0 | 26878 | 0 | 0 |
| 4920 | 15212 | 0 | 26878 | 0 | 0 |
| 4928 | 15212 | 0 | 26878 | 0 | 0 |
| 4936 | 15212 | 0 | 26878 | 0 | 0 |
| 4944 | 15212 | 0 | 26878 | 0 | 0 |
| 4952 | 15212 | 0 | 26878 | 0 | 0 |

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|---|---|---|---|---|---|
| 4960 | 15212 | 0 | 26878 | 0 | 0 |
| 4968 | 15212 | 0 | 26878 | 0 | 0 |
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| 4992 | 15212 | 0 | 26878 | 0 | 0 |
| 5000 | 15212 | 0 | 26878 | 0 | 0 |
| 5008 | 15212 | 0 | 26878 | 0 | 0 |
| 5016 | 15212 | 0 | 26878 | 0 | 0 |
| 5024 | 15212 | 0 | 26878 | 0 | 0 |
| 5032 | 15212 | 0 | 26878 | 0 | 0 |
| 5040 | 15212 | 0 | 26878 | 0 | 0 |
| 5048 | 15212 | 0 | 26878 | 0 | 0 |
| 5056 | 15212 | 0 | 26878 | 0 | 0 |
| 5064 | 15212 | 0 | 26878 | 0 | 0 |
| 5072 | 15212 | 0 | 26878 | 0 | 0 |
| 5080 | 15212 | 0 | 26878 | 0 | 0 |
| 5088 | 15212 | 0 | 26878 | 0 | 0 |
| 5096 | 15212 | 0 | 26878 | 0 | 0 |
| 5104 | 15212 | 0 | 26878 | 0 | 0 |
| 5112 | 15212 | 0 | 26878 | 0 | 0 |
| 5120 | 15212 | 0 | 26878 | 0 | 0 |
| 5128 | 15212 | 0 | 26878 | 0 | 0 |
| 5136 | 15212 | 0 | 26878 | 0 | 0 |
| 5144 | 15212 | 0 | 26878 | 0 | 0 |
| 5152 | 15212 | 0 | 26878 | 0 | 0 |
| 5160 | 15212 | 0 | 26878 | 0 | 0 |
| 5168 | 15212 | 0 | 26878 | 0 | 0 |
| 5176 | 15212 | 0 | 26878 | 0 | 0 |
| 5184 | 15212 | 0 | 26878 | 0 | 0 |
| 5192 | 15212 | 0 | 26878 | 0 | 0 |
| 5200 | 15212 | 0 | 26878 | 0 | 0 |
| 5208 | 15212 | 0 | 26878 | 0 | 0 |
| 5216 | 15212 | 0 | 26878 | 0 | 0 |
| 5224 | 15212 | 0 | 26878 | 0 | 0 |
| 5232 | 15212 | 0 | 26878 | 0 | 0 |
| 5240 | 15212 | 0 | 26878 | 0 | 0 |
| 5248 | 15212 | 0 | 26878 | 0 | 0 |
| 5256 | 15212 | 0 | 26878 | 0 | 0 |
| 5264 | 15212 | 0 | 26878 | 0 | 0 |
| 5272 | 15212 | 0 | 26878 | 0 | 0 |
| 5280 | 15212 | 0 | 26878 | 0 | 0 |
| 5288 | 15212 | 0 | 26878 | 0 | 0 |
| 5296 | 15212 | 0 | 26878 | 0 | 0 |
| 5304 | 15212 | 0 | 26878 | 0 | 0 |
| 5312 | 15212 | 0 | 26878 | 0 | 0 |
| 5320 | 15212 | 0 | 26878 | 0 | 0 |
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